CEMENT
AND
CEMENT MANUFACTURE

PUBLISHED 20TH OF EACH MONTH. PRICE 1/- A COPY. ANNUAL SUBSCRIPTION 12s. POST FREE.

PUBLISHED BY CONCRETE PUBLICATIONS LTD.,
20, DARTMOUTH STREET, LONDON, S.W.1.
TELEPHONE: WHITEHALL 4581.
TELEGRAPHIC ADDRESS:
CONCRETIUS, PARL, LONDON.

PUBLISHERS OF
"CONCRETE & CONSTRUCTIONAL ENGINEERING"
"CONCRETE BUILDING & CONCRETE PRODUCTS"
"CEMENT & CEMENT MANUFACTURE"
"THE CONCRETE YEAR BOOK"
"CONCRETE SERIES" BOOKS, ETC.

VOLUME 5. NUMBER 6. · JUNE 1932

The Future of the Rotary Kiln

DURING the thirty-five years since its commercial application to the cement industry the rotary kiln has been the subject of steady development, and there is no reason to suppose that finality has been reached either in design or efficiency. Compared with its progenitor of 60 ft. in length and 6 ft. in diameter, the modern rotary kiln has reached 400 ft. in length and 12 or 14 ft. in diameter; but it is fairly safe to say that the maximum in length has been reached, because in addition to the mechanical difficulties and high cost of very long kilns there is a lack of evidence that further improvements in efficiency are obtainable with increased length. A 400-ft. kiln does not compare favourably in output (on the basis either of cubic capacity or of unit length) with kilns of half that length, and there are reasons to believe that the smaller kilns are not necessarily less efficient in fuel consumption. The sole advantage remaining with the long kiln appears to be in its aggregate output over a period.

The position in regard to kiln diameter is not so certain; in various kilns there is enlargement of the diameter (compared with the kiln as a whole) at three distinct places, viz., the burning zone, the decomposition or decarbonating zone, and the slurry drying zone. There are many advocates of the enlarged burning zone, and in fact the most popular design of to-day seems to be one with an increased diameter of about 2 ft. in the burning zone, such enlargement continuing for about one-fifth of the length of the kiln and thus including a portion of the decarbonating zone. There are, however, some who say the decarbonating zone should have the largest diameter of any part of the kiln, the argument being that this is the most difficult stage in the burning process demanding great heat absorption at a high temperature, and that consequently the design should be such that the passage of the material along the kiln is checked at this stage. There are also advocates of the enlarged drying zone who consider that in this position a large volume is needed to permit of sufficient chains or other devices being fitted to extract the heat from the exit gases.

An entirely new aspect is, however, given to the subject in a book recently published* which both kiln designers and operators would do well to consider. The author shows by means of calculation that the efficiency of a rotary kiln is

* "Chemical Engineering and Thermodynamics applied to the Cement Rotary Kiln," by Geoffrey Martin. Pp. 268. Price 31/6. Published by Crosby Lockwood & Son, and obtainable through Concrete Publications, Ltd., 20, Dartmouth Street, London, S.W.1.

very largely dependent on the flame temperature, and the higher this is the lower will be the fuel consumption. Anything that occurs to reduce the flame temperature will increase fuel consumption, and this may happen through (1) insufficiently heated air for combustion, (2) radiation of heat from the kiln shell, or (3) radiation within the kiln from the burning zone to the drying zone or even to the kiln flues.

The first two sources of loss have had the consideration of cement manufacturers for many years, and the integral cooler has been one means of raising the temperature of the combustion air. Attempts to prevent radiation from the kiln shell in the flame zone have been hampered by the absence of lining blocks of the required degree of refractoriness, although high alumina blocks have been of some assistance in this direction. It is, however, the internal radiation that is apparently the most serious cause of flame temperature reduction, and the one that demands the most radical changes in kiln design and operation. It needs to be emphasised that radiant heat behaves similarly to light, and any part of the inside of a rotary kiln that is illuminated (so to speak) by the flame or the hot walls of the burning zone is receiving radiant heat, and conversely the flame is becoming colder by the loss of such heat. Wherever it is possible by looking into the back end of a kiln to see any brightness, radiant heat is not only reaching the observer's eye but is also reaching the flue beyond which the observer stands and causing a total loss of heat.

The modern method of avoiding this loss of radiant heat is to crowd the drying zone with obstructions, such as chains and slurry lifters, but this is only a partial remedy because these devices merely use the radiant heat in slurry drying for which purpose there is already a surplus of heat available, as witness the high exit-gas temperature of rotary kilns. The author proceeds to emphasise what every chemist knows, viz., that the critical operation in a rotary kiln is the decomposition of calcium carbonate, which can only take place at a temperature above 1,481 deg. F. Hence it is of prime importance that heat should be conserved in the kiln above this temperature, and any high-temperature heat units radiated away to the drying zone are practically wasted. By calculation it is shown that, if internal radiation is prevented, fuel consumption in the wet process should be reduced to well under 20 per cent. of the clinker output.

It is too much to expect to find the practical application of these principles described in a text book, and those cement manufacturers who are convinced of their truth will have to devise their own methods of preventing the dissipation of radiant heat. A striking example of the validity of the ideas can, however, be found in the working of a kiln (described in this journal for April, 1932, page 142) which appears to be the most economical in fuel at the present time. In an ordinary dry-process kiln all the interior is subject to the action of radiant heat from the flame, and in consequence the loss of heat in the exit gases is very great. In the two-stage kiln referred to (consisting of a travelling grate for drying and partly decarbonating and a short rotary kiln for the completion of decarbonation and clinkering) there is practically no possibility of radiant heat escaping from the rotary kiln portion of the system, and all such heat is utilised in decarbonation. The drying of the damp raw-material nodules and the preliminary heating are done alone by actual contact with hot gases. In practice, the exit gases leave the travelling grate at a temperature of less than 400 deg. F., a figure hitherto not attained in the dry process of manufacture. This is in itself an indication that in the ordinary dry-process single rotary kiln the exit gases which usually escape at a temperature of 1,100 deg. F. are carrying away heat from the burning zone. By preventing this, the two-stage burning process has a fuel consumption of about 15 per cent. of the clinker production, or roughly threequarters of the

normal consumption for the dry process. According to the theories of the author of the book, any fuel saving has a cumulative effect because the smaller volume of combustion air passing over the same weight of hot clinker issuing from the kiln becomes heated to a higher temperature and adds still further to the flame temperature with beneficial effects to heat economy.

As already indicated, the author has not ventured far in the practical application of his ideas, but it is surprising that the two-stage rotary kiln for the wet process has not been mentioned. It is an old suggestion that the rotary kiln should be in two distinct parts—one for drying the slurry and partially decarbonating, and the other for completing the burning operation—and although never adopted for Portland cement, probably on account of mechanical complications, it demands reconsideration in the light of the high-temperature flame theory. The question for decision is whether the saving of, say, one hundredweight of fuel per ton of clinker is sufficient compensation for the cost and labour involved in building and running two rotating drums instead of one, together with the accompanying additional air seals, etc. The answer depends on the value of one hundredweight of fuel and upon how much it is worth sacrificing to retain the simplicity of the single rotary kiln.

The problem of altering and operating the single rotary kiln so as to reduce heat radiation losses from the burning zone still remains and is not easy to solve, but it is obvious that prejudices still prevalent against getting the burning zone too hot and in favour of heat recovery from kiln exit-gases must be resisted. If the heat in a rotary kiln is used in its proper place there will be only negligible quantities to recover either in waste-heat boilers or elaborate slurry-lifting devices within the kiln; moreover, there will be no need for kilns of inordinate length.

New German Standard Specification for Cements.

THE new German specification for cements, of which an outline was given in CEMENT AND CEMENT MANUFACTURE for December, 1930, has now been accepted by the Minister for Commerce and referred to the competent state and provincial authorities for official adoption. Since 1930 the specification has been amplified and modified in certain respects. It provides for continuous supervision of the works which adopt it, and the 1932 Regulations of the German Ferroconcrete Commission prescribe the use of cement from controlled works, as do also other official regulations. Cement from such works is indicated by the "Standard Control" mark on the packing. The use of this mark and the supervision of manufacture are to become operative in October 1932. Section 19 of the specification lays down the lines along which the supervision is to be exercised. Any works repeatedly failing to comply with the specification will lose the right to use the control mark and to designate its cement "standard."

For high-strength cement packed in paper bags, green bags must be used, and this colour is not allowed for packing other cements; this regulation also comes in force in October 1932.

The scheme of chemical analysis given in CEMENT AND CEMENT MANUFACTURE for September 1931, as modified in our number for March 1932 (p. 98), is to be used.

In cases of dispute as to strength, the tensile and crushing strengths at 3 or 7 days and after 28 days combined storage are authoritative. The strengths after 28 days water storage are only authoritative in special cases of mutual agreement.

The conditions for passing the boiling test are made more stringent. If the cement does not withstand this test it must be repeated with cement which has been exposed to the air for three days in a layer 5 cm. thick.

The Rotary Kiln in Cement Manufacture.—XII.

By W. GILBERT, Wh.Sc., M.Inst.C.E.

(Continued.)

Recorder Charts.

Kiln-speed Chart.—(182) A chart for the twenty-four hours ending at noon on January 24 is shown in Fig. 60. It will be seen that the kiln was frequently placed on half speed in order to cope with the approach of relatively under-burned material to the clinkering zone.

Chart of Kiln Exit Gas Temperature.—A reproduction of a chart taken over the twelve-hour period ending noon on January 24 is shown in Fig. 61. The pyrometer, a thermo-couple in a steel sheath, was placed in a vertical position opposite the kiln end and about 4 in. in front of it. It was not shielded from radiation loss so that the readings are probably about 100 deg. F. too low. The chart gives a good idea of what the average exit gas temperature may be in a modern wet-process kiln when the area of the surface added to the upper end of the kiln in the shape of slurry lifters or similar is limited. The excessive temperature fluctuations are somewhat difficult to account for, as they do not correspond to the placing of the kiln on half speed (and the consequent deflection of the slurry nozzle). This may be seen by comparing the record for the last twelve hours in Fig. 60 with Fig. 61. Apparently, therefore, they are caused by variations in the coal feed.

Coal-screw Speed.—(183) Recorders were applied to the two coal screws as described in connection with plant B, and the combined chart for the 24 hours ending January 21 is shown in Fig. 62. The speed scale on the diagram is proportional to the actual speeds. The value of the coal-screw speed charts can only be seen when reading them in conjunction with a series of waste-gas analyses as made by the Orsat apparatus.

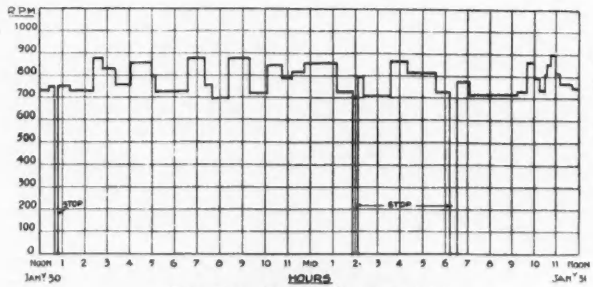
Uniformity of Coal Feed.

A coal feed is considered to be uniform when the same weight of coal is delivered for each revolution of the feed screw whatever the actual speed, within reasonable limits, may be.

Coal By-pass Tests.—(184) Arrangements were made whereby the coal delivered to each branch of the coal-firing pipe could be diverted into a bag during a definite number of screw revolutions, usually 50, the bag being afterwards weighed. From fifty revolutions of each screw the total coal obtained varied from 59 to 68 lb., but one low reading of 47 lb. was recorded. Fourteen readings were taken from each coal screw, and the average of the 28 deliveries was 61.64 lb. It was considered that these observations were insufficient, partly because they were not made under working conditions, and a further investigation was arranged.

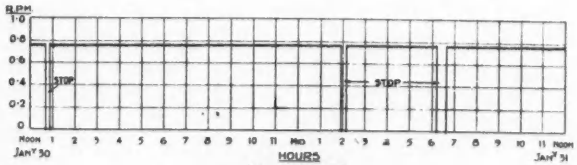
Relation Between Coal-screw Speed and Exit Gas Analysis.

(185) Throughout the test the kiln exit gases were analysed by the Orsat apparatus twice per hour during the day, and each time the gas was drawn into the Orsat apparatus the corresponding revolutions per minute of each coal screw were recorded. The gas analysis was made by an experienced chemist, and considerable care was taken to ensure that the collecting pipe was not choked with slurry, also that leakage into the gas-collecting system did not occur.



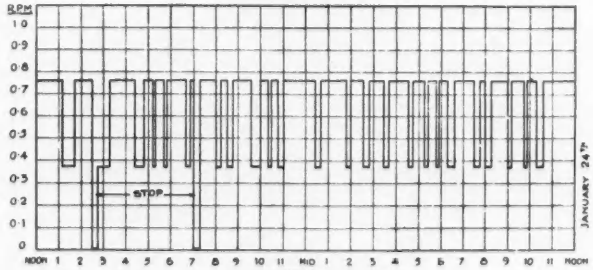
COAL FEED SCREWS, RELATIVE SPEED
KILN PLANT B

FIG: 58



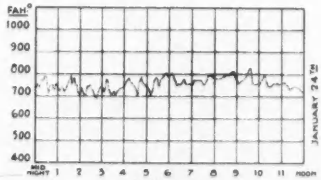
KILN SPEED
KILN PLANT B

FIG: 59



KILN SPEED
KILN PLANT C

FIG: 60



KILN EXIT GAS TEMPERATURE.
KILN PLANT C

FIG: 61

The following data relating to the kiln test are required to complete the calculations:

(*a*) Air required for combustion per lb. of coal .. .. 8.5 lb.
(*b*) Average air supply to kiln per minute .. .. 854 lb.
(*c*) CO_2 from combustion per lb. of coal .. .. .. 2.33 lb.
(*d*) CO_2 from raw material per lb. of coal .. .. 1.61 lb.
(*e*) Nitrogen used per lb. of coal .. .. .. 6.53 lb.

(186) A selection of the observations and of the calculated results is given in Table XVI.

TABLE XVI.

Coal-screw revolutions per minute (added).	O_2 per cent. in exit gases.	Excess air per cent.	Air used per minute lbs.	Coal delivered per minute lbs.
(1)	(2)	(3)	(4)	(5)
115.5	1.80	10.3	774	91.0
115.5	3.40	21.2	704	82.8
160.0	0.80	4.3	819	96.4
160.0	5.40	38.1	618	72.8

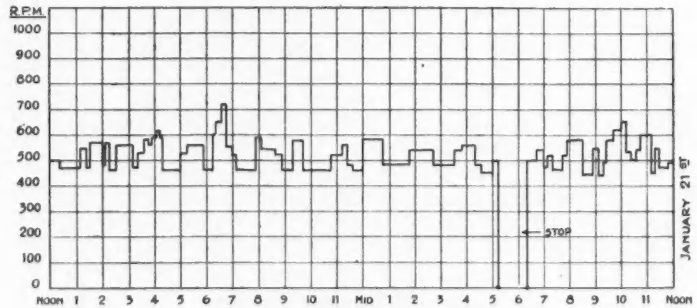
Four of the half-hourly observations are given in columns (1) and (2). To obtain the excess air used, as listed in column (3) from the O_2 readings in column (2), formula (9) in para. (53) is used (see November, 1930, number). Referring to lines (*c*), (*d*), and (*e*) in para. (185), we have $A=3.94$ and $N=6.53$, so that the formula reduces to $E=\dfrac{79.52X}{15.18-0.727X}$

(187) Taking for example line (4) in the Table $X=5.4$, and $E=\dfrac{79.52\times5.4}{15.18-(0.727\times5.4)}=\dfrac{79.52\times5.4}{11.26}=38.1$ per cent., as tabulated in column (3).

Hence, from line (*b*) in para. (185) the air per minute actually used for combustion is $\dfrac{100}{138.1}\times854=618$ lb., and the coal burned per minute, from line (*a*) para. (185) is $\dfrac{618}{8.5}=72.8$ lb.

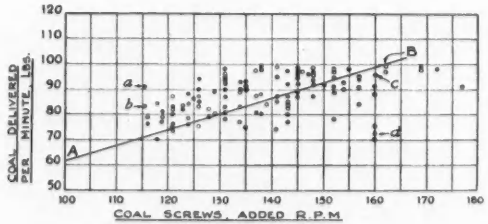
These results, together with all the others, are plotted in Fig. 63; the figures in column (1) of Table XVI are plotted against the figures in column (5). For instance, from the first line of Table XVI it is seen that 115.5 coal-screw revolutions per minute gave a delivery of 91 lb. of coal. This observation is denoted by point (a) on the graph. The remaining lines of the table correspond to the points b, c, and d on the graph. The coal by-pass readings, see para. (184), gave an average delivery of 0.6164 lb. per revolution, and this result is represented on the diagram by the line *AB*.

(188) The max. quantity of coal which can be completely burned per minute is $\dfrac{854}{8.5}=100$ lb. nearly, and the corresponding coal-screw revolutions are $\dfrac{100}{0.6164}=162$. A delivery of 100 lb. per minute at 162 revolutions is denoted by point *B* on the diagram, and the delivery of 61.64 lb. at 100 revolutions is denoted by point *A*. If the coal screws throughout the test delivered 0.6164 lb. of fine coal per screw revolution and if all the Orsat readings were representative, all



COAL FEED SCREWS, RELATIVE SPEED
KILN PLANT C

FIG:62



KILN PLANT C

FIG:63

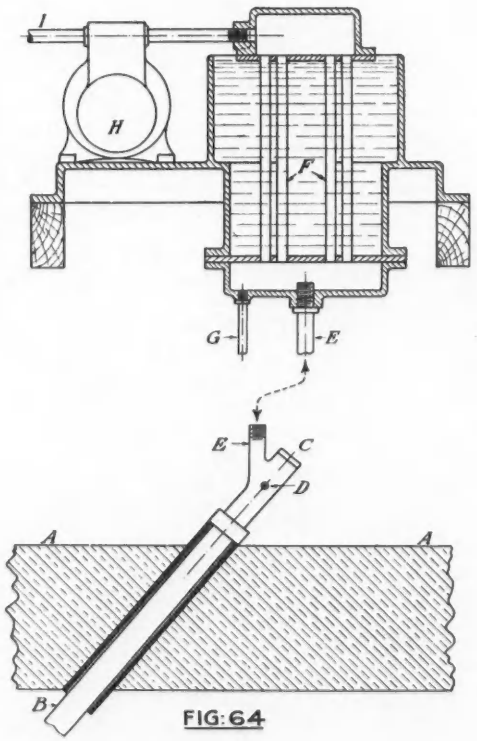


FIG:64

the points in Fig. 63 should fall on the line *AB*. It will be seen, however, that there is no real relation between the speed of the coal screws and the weight of coal delivered by them per minute. Apparently the speed of the screws was altered by the burners in order to keep the coal feed regular, *i.e.*, in order to prevent it from being more variable than it would otherwise have been.

Indicating and Recording Instruments for Daily Use.

(189) Paragraphs (163) to (188) deal with measurements mainly from the point of view of the kiln manufacturer or cement maker wishing to improve his plant; it is now proposed to look into the requirements of the works manager or burner who wishes to increase the efficiency of existing kilns.

The main object as regards the kiln is to see that no heat is wasted and no output lost. Instruments are therefore required to measure the chief losses or leakages of heat from the kiln which may be prevented or minimised. It is necessary to ensure that each pound of coal burned receives its proper supply of air at the maximum preheat; the cooler efficiency is therefore involved, and the heat abstracted for coal drying must be taken into account.

(190) As an example, it is proposed to consider the application of the instruments suggested for day to day use on a kiln with an integral cooler, the output being about 18 tons of clinker per hour. The following is a summary of the measurements to be made:—

(*a*) At the upper end of the kiln arrangements are made for periodically withdrawing a small quantity of exit gas and pumping it to the burning platform where it is examined for percentage of oxygen.
(*b*) The exit gas temperature is measured by a thermo-couple (protected from radiation) connected to a temperature indicator on the burning platform.
(*c*) The draught in the kiln flues is shown by a dial gauge on the burning platform.
(*d*) At the firing end means are provided for determining the temperature of the air leaving the cooler tubes (or the preheat), and a check is kept on the quantity.
(*e*) Measurement is made of the weight of hot air per minute taken from the kiln end for coal drying.
(*f*) A speed recorder is applied to the kiln gearing.

Measurements at the Upper End of the Kiln.

Waste Gas Analysis.—(191) CO_2 recorders are widely used for waste gas analysis in connection with steam boilers, but they are not so suitable for use with rotary kilns. The reasons for this were given in para. (51) (see November, 1930, number). An efficient oxygen recorder is required. The types now obtainable have not been widely used, since they are somewhat troublesome to keep in working order. The writer gave some particulars with reference to the application of an oxygen recorder in article II, March, 1930, number.

For the present purpose arrangements are made to pump a small quantity of the exit gas to the burning platform, once per hour or as required, in order that the burner may test it for oxygen content. A single element of the Orsat apparatus is used. The gas collecting pipe is 1¼ in. in diameter. It is inclined at 50 deg. and projects about 6 in. into the end of the kiln. The method of cooling the gas and draining off the water is shown in Fig. 64. The condensing arrangement consists of 24 brass tubes ½ in. in diameter and 12 in. long immersed in a vessel of water. A small electrically driven blower delivers about 3 cub. ft. of gas per minute to the burning platform through a ½ in. diameter pipe under

a slight pressure. On the suction side all the pipe joints require to be welded or otherwise made air tight.

(192) The method of supplying the analyser on the burning platform is shown in Fig. 65. Gas from the $\frac{1}{2}$ in. diameter pipe line *A* enters a small vessel *B*; it can escape freely to the atmosphere through a $\frac{1}{4}$-in. diameter nozzle at *C*, but the vessel is maintained under slight pressure. Gas is delivered to the analyser through the valve *D*. The gas blower is large enough to clear the pipe-line in half a minute, so that it need only be switched on from the burning platform for about a minute before a reading is taken. The escape of gas at *C* is an indication that the blower is working satisfactorily.

Since the oxygen reading is alone required, the analyser consists of a single absorption vessel containing phosphorus, and the gas-measuring tube is so

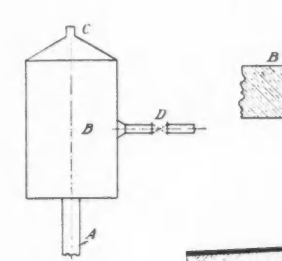


FIG 65

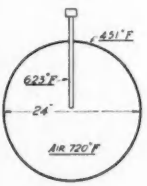


FIG 68

Fig. 66.—A, upper end of kiln; B, roof of flue; C, gas-collecting pipe; D, multiple bush; E, exposed thermo-couple; F, discharge ports for gas; G, pyrometer in steel sheath.

Fig. 67.—A, kiln firing end: B, cooler tubes; C, fixed front hood; D, door 5' 6" × 3'; E, loose ring packing; F, coal firing pipe; G, pipe to coal drier: H, M.B. pyrometer; I, connection for draught gauge; J, connection for differential gauge.

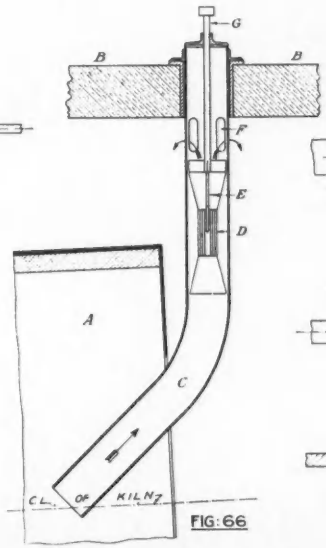


FIG 66

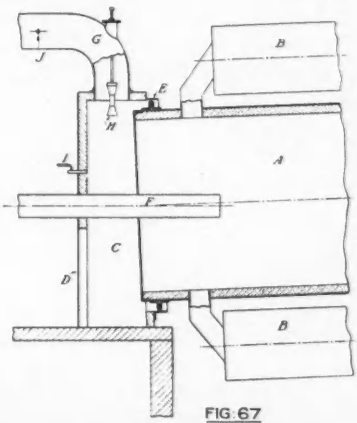


FIG 67

arranged that quantities of from $\frac{1}{2}$ to 3 per cent. can be read off with considerable accuracy. The burner should be supplied with a copy of the average O_2 curve shown in Fig. 27, and the observations are preferably recorded once per hour in a book provided for the purpose. A connection is made to the gas-collecting pipe at *D* just above the flue roof (see Fig. 64) in order that check readings by an Orsat apparatus may occasionally be made whilst the gas blower is running.

Kiln Exit Gas Temperature.—(193) To obtain a true reading of the kiln exit gas temperature it is necessary to prevent radiation from the thermo-couple to the relatively cold surfaces inside the kiln end, and the arrangement shown in Fig. 66 has proved suitable for the purpose. To increase the heating effect, the thermo-couple is left exposed and the hot gas is caused to flow over it at considerable velocity, the pressure difference inside and outside the kiln end being used for this purpose. The couple is also surrounded by a metallic surface, the temperature of which is practically the same as that of the gas which is to

be measured so that loss of heat by radiation is eliminated. The vertical arrangement of the pyrometer and multiple bush prevents the lodgment of sludge or dust.

(194) The following figures give an average of the comparative readings taken over a considerable period at the end of a wet-process rotary kiln:

	Deg. F.
(*a*) Multiple bush pyrometer in accordance with Fig. 66 ..	860
(*b*) Normal type of pyrometer in steel sheath	716
Difference	144

Temperature Indicator.—Either a recorder or an indicator may be used on the burning platform in connection with the kiln exit gas pyrometer, but the writer considers an indicator will give sufficient information for operating purposes, the burner being instructed to book the readings once per hour.

Measurements at the Firing End of the Kiln.

(195) It is impossible to make an accurate observation of the temperature of air leaving the cooler tubes unless leakage of cold air into the end of the kiln is prevented. Existing arrangements of an integral cooler are often faulty in this respect, as there is a good deal of leakage around the fixed end plate and insufficient space is provided for the pipe connection which draws off hot air for coal drying. Unless leakage is prevented, the efficiency and the capacity of the integral cooler may easily fall below that of the independent type, since the former rotates more slowly, and is thus less suitable for heat transfer. Hence the writer suggests the arrangement shown in Fig. 67. A fixed front hood is used, and proper facilities are provided for taking off hot air and for packing the running joint.

With leakage prevented, the air supply to the kiln should all come through the cooler tubes since the air drawn off to dry the coal will eventually be used as the primary air supply. Since the cooler tubes are not under forced draught, the draught in the kiln end *A* or in the hood *C* will be a measure of the quantity of air which is being drawn through them, provided the resistance of the group of tubes to air flow is constant and under normal conditions of working this should be the case.

(196) A dial draught-gauge is used to measure the depression in the hood *C*, the connection being made at *I*. Provision is made so that the pipe end may be cleared of dust. When the kiln is working under normal conditions the proper draught to use in the front hood will be that which corresponds to about 1 per cent. of O_2 in the exit gas analysis. A usual value is 0.75 in. W.G., and this draught (whatever it may be) requires to be kept constant by regulating the chimney damper or the speed of the induced draught fan if the resistance inside the kiln to the passage of the hot gases is variable.

Measurement of Preheat.—(197) Allowing for the radiation loss from the cooler tubes and for hot clinker loss at the delivery end, it will be found that the temperature of the air which enters the kiln from the cooler will be about 720 deg. F. A continuous measurement of this temperature is required. If the kiln hood is lined with firebrick and the running joint properly packed, the air entering the pipe *G* (Fig. 67) will be approximately at the same temperature as that leaving the cooler tubes, but this temperature cannot be measured correctly by merely inserting a pyrometer into the pipe, as the following calculation will show.

The pipe *G* is taken to be 24 in. in diameter, and 300 lb. of air at 720 deg. F. are assumed to be drawn off per minute for coal drying. Let Fig. 68 represent

a cross-section of the pipe. It is first required to determine the temperature of the pipe wall. The area of the pipe in cross-section is 3.14 sq. ft., so that if W represents the weight of air flowing per hour per sq. ft. of cross-section, we have:

$$W = \frac{300 \times 60}{3.14} = 5740.$$

The corresponding value of the convection constant H_c is taken at 5.7 B.T.U. per sq. ft. per hour per deg. F.

Proceeding by trial and error, the wall temperature is assumed to be 451 deg. F., which leads to the following statement:

	B.T.U.
(*a*) Heat transferred by convection from hot air at 720 deg. F. to wall of pipe, per sq. ft. per hour $= 5.7\ (720-451)$	= 1534
(*b*) Heat radiated from outer surface of pipe to atmosphere per sq. ft. per hour (see Table IV., July, 1930)	= 1531

(The pipe wall being of thin steel plate, the temperature gradient in it is neglected.)

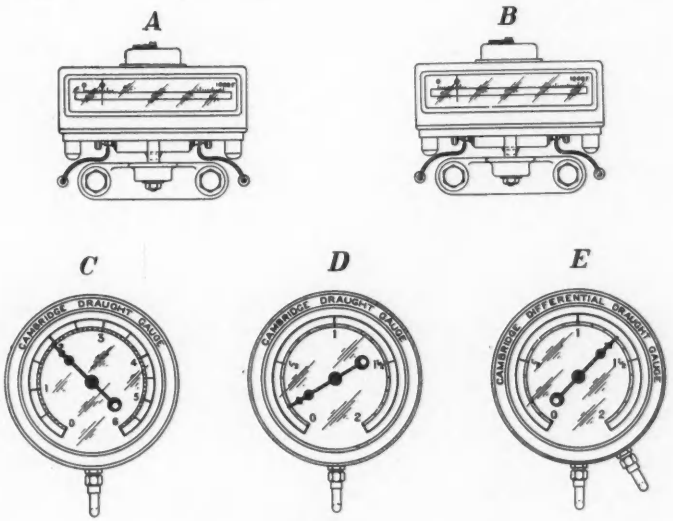


FIG. 69

Back Plate of Instrument Cupboard.

Hence the temperature assumed for the pipe wall is correct, since the heat gained by it is equal to the heat lost.

(198) To obtain the reading of the pyrometer it is to be noted that the heat supplied from the gas at 720 deg. F. to the pyrometer stem by convection must be equal to that radiated from the pyrometer stem to the wall, which is at a

temperature of 451 deg. F. If the stem is about $\frac{5}{8}$ in. in diameter, and $W = 5740$, the value of H_c as derived from various experiments may be taken at 15.0. Proceeding again by trial and error, the pyrometer is assumed to read 623 deg. F., thus leading to the following statement:

	B.T.U.
(*a*) Heat transferred from the air at 720 deg. F. to the pyrometer stem by convection, per sq. ft. per hour $= 15\ (720 - 623) = 15 \times 97$	= 1455
(*b*) Heat radiated from the pyrometer stem at 623 deg. F. to the pipe wall at 451 deg. F. per sq. ft. per hour, from Table IV $= 2986 - 1531$..	= 1455

Hence the temperature assumed for the pyrometer stem is seen to be correct, and the reading error is $720 - 623 = 97$ deg. F.

(199) To obtain a satisfactory measurement of the preheat temperature the multiple-bush pyrometer shown at *H* in Fig. 67 is used. To produce the velocity with which the air enters the pipe *G* (the flow being 300 lb. per minute at 720 deg. F.) a pressure difference of about 0.60 in. W.G. will be required. This pressure difference is used to give the required air flow through the multiple bushes of the pyrometer. A suitable temperature indicator is provided.

Air Supply to Coal Drier, or Coal Mill.—(200) This quantity may be continuously measured by observing the pressure difference between the front hood *C* and a convenient point *J* in the pipe line (see Fig. 67). The pressure difference required to start the air flow into the pipe *G* was stated to be about 0.60 in. W.G., and the differential pressure referred to will be rather more. It can be measured by a differential dial gauge. The connection at *J* should be made by a $\frac{1}{4}$ in. pipe finished flush with the inner face of the tube. The other connection may be made at *I*. A formula will be required to connect the reading of the differential gauge with the weight of air flowing along the pipe per minute, hence a measurement must be made of the latter.

Suitable measuring apparatus is provided in the Pitot tube shown in Fig. 13 and the tilting water gauge shown in Figs. 14, 15, and 16 (see March, 1930, number).

(201) The mean value of $\sqrt{i}$ (the square root of the velocity gauge) at the cross-section having been obtained, the weight of air flow is calculated by Table I (May, 1930). Suppose the result to be that a flow of 290 lb. per minute, at a temperature of 720 deg., corresponds to a differential gauge reading of 0.65 in., the height of the barometer being $29\frac{1}{2}$ in. A formula is required which will give the weight of air flow under other conditions of air temperature, differential gauge reading, and height of barometer. The formula given in Table I is applicable provided that the "equivalent pipe area" is known. This may be denoted by *Ae*. Putting numerical values into the formula of Table I we obtained

$$290 = 201 \times Ae \times \sqrt{\frac{0.65 \times 29.5}{30}}$$

$$\therefore\ Ae = 1.73 \text{ sq. ft.}$$

Example.—Suppose the air temperature falls to 600 deg. F., the differential gauge reading being 0.59 in. and the height of the barometer 30.5 in. Since the equivalent pipe area is 1.73 sq. ft., the required air flow is

$$W = 212 \times 1.73 \times \sqrt{\frac{0.59 \times 30.5}{30}}$$

$$\therefore\ W = 212 \times 1.73 \times 0.775 = 284 \text{ lb. per minute.}$$

Instrument Cupboard.—(202) The various instruments on the burning platform can conveniently be housed in a cupboard with glass doors. A view of the back of the cupboard, on which the instruments are mounted, is shown in Fig. 69. A list is as follows: A, temperature indicator for kiln exit gases, reading 0 deg. to 1,000 deg. F.; B, temperature indicator for preheat, reading 0 deg. to 1,000 deg. F.; C, dial draught gauge for kiln flues, reading 0 to 6 in. water gauge; D, dial draught gauge for kiln hood, reading 0 to 2 in. water gauge; E, differential dial gauge for measuring weight of hot air taken for coal drying.

Notes from Abroad.

The Japanese Cement Industry.

Commenting on the Japanese Portland cement industry, the Mitsubishi Economic Research Bureau states:

The output of cement was reduced to less than 300,000 tons per month during the latter half of last year, the restriction ratio being as high as 57 per cent. of capacity. An alleviation of the existing curtailment, which was fixed at 52 per cent. for March, to 50 per cent. for April and May in order to counterbalance the shortage in stocks has been agreed upon by the Cement Manufacturers' Association.

Sales for the home market showed no more than the usual activity during last autumn, but the seasonal decline in winter was far less than normal, sales totalling 725,141 tons during the three months beginning December of last year, an increase of 25.1 per cent. compared with the previous year. In addition to the unusually mild winter, Government works for the relief of employment greatly strengthened the market. Deliveries in March were, however, rather less than expected, the domestic demand reaching only 291,652 tons.

Exports were rather unsatisfactory during the past year on account of the anti-Japanese boycott and other troubles in China, as well as tariff increases in other Far Eastern countries. A slight improvement was witnessed early this year, but the volume again declined to 24,585 tons in March, the lowest during the past two years. A substantial recovery in exports is not expected in the immediate future, though some orders may be secured from Manchuria.

With the satisfactory development in sales, stocks showed a fair decrease; total holdings reached 208,111 tons at the end of February and 219,570 tons at the end of March, a reduction of 26.7 per cent. and 10.7 per cent. respectively compared with the previous year.

Cement Sales in Germany.

Cement sales by the Deutscher Zement Bund for the month of April 1932 were 339,000 tons compared with 434,000 tons for the corresponding period in 1931. The total sales for the four months January to April 1932 were 724,000 tons against 1,064,000 tons in 1931.

Westdeutscher Zement Verband reports a decrease of 48 per cent. in the sales of cement for the first three months of 1932 compared with the corresponding period in 1931.

Belgian Cement Output.

The output of cement in Belgium for the month of April, 1932, was 34 per cent. of an estimated annual productive capacity of 4,000,000 tons. This compares with 48.8 per cent. for April 1931. The deliveries in April 1932 were 48.4 per cent. of total capacity compared with 50.4 per cent. in April 1931.

THE BELGIAN CEMENT INDUSTRY.

A report issued from the British Embassy at Brussels states that a profound feeling of depression characterised the Belgian cement industry during the year 1931. Sales fell and the decline in exports noted during the latter part of 1930 was even more marked in 1931.

Exports during the first nine months of 1931 fell to 1,022,166 tons (as against 1,420,627 tons and 1,270,869 tons in the corresponding periods of 1929 and 1930), of a value of 194.8 million francs, compared with 351.7 million francs in 1929 and 300.8 million francs in 1930. Exports to Argentina fell from 128,327 tons in the period January to September 1930 to 38,798 tons in January to September 1931. Exports to the United States were only 13,556 tons during the first nine months of 1931, compared with 158,534 tons in the first nine months of 1929. Big declines have also been registered in 1931 in exports to Brazil and the United Kingdom, while exports to Morocco and Holland showed an increase.

Exports account for 55.5 per cent. of the Belgian production, and prices have fallen below cost. The abandonment of the gold standard in Great Britain led to a cessation of orders from that market.

The internal market was also calm and prices showed a weakening tendency as a result of the competition among producers who could no longer sell at remunerative prices overseas. Wages fell by from 5 to 10 per cent., and the cost of fuel was reduced, but nevertheless the industry is in a stagnant condition. A number of works are closed down and others are working on one kiln instead of three or four. The following figures show the percentage relation between the effective output and the potential capacity of the industry as a whole during the first nine months of 1931: January, 36; February, 38; March, 44.5; April, 48.8; May, 57.5; June, 53.24; July, 56; August, 61; September, 60.

The capital invested in the Belgian cement industry is estimated to be as follows: Fixed, 800 million francs; liquid, 300 million francs; portfolios, 100 million francs. It is estimated that the net yield on this capital was less than 2 per cent. for the year 1931.

Negotiations having as their object a general sales agreement for the Belgian market have been in progress among Belgian manufacturers during 1931, but they have been unsuccessful. The agreement arrived at was a division of factories into four groups—a northern group (under the C.B.R.), a southern group, and two groups for the Tournai district. Each group would have had a sales office had this scheme materialised, personal relations between factory and client being suppressed.

Paper Bags for Cement.

It is stated that the proportion of paper bags used for packing the cement produced by the French concern Etablissements Poliet et Chausson increased from 22.5 per cent. of the total sales in 1930 to 31.5 per cent. in 1931, and that it is hoped to increase this figure to 50 per cent. this year.

Cement Output in the United States.

The United States Bureau of Mines gives the cement output for the period January to March, 1932, as 13,844,000 barrels, which compares with 20,860,000 barrels for the same period in 1931. The sales for the same period of 1932 were 10,484,000 barrels, compared with 16,958,000 barrels for the same period in 1931. The percentage of production based on total capacity for the month of March 1932 was 21.3 compared with 36.9 in 1931. The percentage of production for the twelve months ending March 1932 was 43.8, while the percentage for the previous year was 58.6.

Hydrothermal Synthesis of Calcium Hydro-Aluminates.

By PROFESSOR SHOICHIRO NAGAI (*Tokio Imperial University, Japan.*)

THE author recently studied the hydrothermal synthesis of calcium hydro-silicates from lime and silica by heating under pressure of saturated water vapour in an autoclave (CEMENT AND CEMENT MANUFACTURE, May 1932), and found some varieties of calcium hydro-silicates, *i.e.*, $2CaO.SiO_2.xH_2O$, $3CaO.2SiO_2.xH_2O$ and $CaO.SiO_2.xH_2O$. Various mixtures of lime and alumina or aluminium hydroxide have since been studied for the hydrothermal formation of calcium hydro-aluminates by the same method of hydrothermal synthesis under pressure. In these studies some varieties of calcium hydro-aluminates, *i.e.*, $3CaO.Al_2O_3.xH_2O$ and $2CaO.Al_2O_3.xH_2O$, were provisionally found. These calcium hydro-aluminates and calcium hydro-silicates have a very important relation to the hydration of the constituents of cements and their hydrated products. T. Thorvaldson and his collaborators have studied the hydration of tricalcium aluminate and found some compounds of tricalcium hydro-aluminates, $3CaO.Al_2O_3.6H_2O$, $3CaO.Al_2O_3.1.5H_2O$, $3CaO.Al_2O_3.H_2O$, etc. (Canadian Journal of Research, 1929, I, 36), and other varieties, $3CaO.Al_2O_3.12H_2O$, $3CaO.Al_2O_3.10.5H_2O$, $3CaO.Al_2O_3.8H_2O$, etc. (National Research Council of Canada, 1929, 201).

In these notes a preliminary report on some results of studies on the hydrothermal synthesis of calcium hydro-aluminates from lime and alumina or aluminium hydroxide are given.

I.—Preliminary Tests of Hydrothermal Synthesis of Calcium Hydro-aluminates from Mixtures of Lime and Alumina or Aluminium Hydroxide.

It was necessary at first to undertake some preliminary studies, and for this purpose two mixtures, Nos. 232 and 254, were made by mixing newly calcined lime and aluminium hydroxide (No. 232) or alumina calcined at 600 deg. C. for three hours (No. 254) in equimolecular proportion, *i.e.*, $CaO:Al_2(OH)_6$ (1:1) or $CaO:Al_2O_3$ (1:1). These mixtures were heated hydrothermally in the following conditions and analysed, as follows:

(*a*) 3 to 5 grs. of the mixtures were weighed in a nickel crucible and then put into a copper box, which was heated in an autoclave in the presence of saturated water vapour at a pressure of 5 kg. per square cm. at a temperature of 152 to 154 deg. C., for a period of one day.

(*b*) The products after heating were dried in a quick-lime desiccator to constant weight.

(*c*) The completely dried products were analysed to ascertain (1) weight increase by the hydrothermal heating; (2) loss on ignition; (3) insoluble residue, by treating with 10 per cent. Na_2CO_3 solution in a water bath, washing with water, and then treating with 5 per cent. HCl solution; (4) free lime, by titrating with Emley's or Lerch and Bogue's method; (5) total lime; (6) combined lime, by the difference between total lime and free lime; (7) percentage of combined lime to total lime; (8) total alumina; (9) soluble alumina from the filtrates in (3); (10) percentage of soluble alumina to total alumina; (11) ratio

between combined lime and soluble alumina; and (12) molecular ratio between combined lime and soluble alumina. The results are shown in Table I.

TABLE I.

RESULTS OF PRELIMINARY TESTS OF HYDROTHERMAL SYNTHESIS OF CALCIUM HYDRO-ALUMINATES FROM MIXTURE OF CaO AND Al_2O_3 OR $Al_2(OH)_6$.

	Sample No. 232.	Sample No. 254.
Mixing proportions	CaO 1 mol. $Al_2(OH)_6$ 1 mol.	CaO 1 mol. Al_2O_3 1 mol.
Heating conditions	5 kg. per sq. cm. 152 to 154 deg. C. 1 day	5 kg. per sq. cm. 152 to 154 deg. C. 1 day
(1) Weight increase	(−)3.05 per cent.	23.14 per cent.
(2) Loss on ignition	23.70 ,,	22.65 ,,
(3) Insoluble residue	31.41 ,,	32.83 ,,
(4) Free lime	3.53 ,,	9.10 ,,
(5) Total lime	27.07 ,,	27.40 ,,
(6) Combined lime	23.54 ,,	18.30 ,,
(7) Percentage of combination of lime	87.0 ,,	66.8 ,,
(8) Total alumina	49.02 ,,	49.55 ,,
(9) Soluble alumina	17.86 ,,	16.72 ,,
(10) Percentage of combination of alumina ..	36.4 ,,	33.7 ,,
(11) Ratio of combined CaO to soluble Al_2O_3 ..	1.32	1.09
(12) Molecular ratio combined CaO to soluble Al_2O_3	2.40	1.98

From these results the following points emerge:

(*a*) In sample No. 232, about 87 per cent. of lime combines with alumina.

(*b*) There is a weight decrease of about 3 per cent. in sample No. 232, instead of an increase of weight of free CaO to $Ca(OH)_2$. This shows the decomposition of aluminium hydroxide to alumina by the hydrothermal heating at 152 to 154 deg. C. at a pressure of 5 kg. per square cm. for one day. When $Al_2(OH)_6$ was alone heated by the same conditions of hydrothermal heating, about two-thirds of hydrated water was lost and became $Al_2O_3.H_2O$.

(*c*) In equimolecular mixture $CaO : Al_2(OH)_6$ (1 : 1) the balance of weight increase of CaO to $Ca(OH)_2$ and weight decrease of $Al_2(OH)_6$ to $Al_2O_3.H_2O$, without any assumption of combination between lime and alumina, is equal to the weight decrease of 1 molecule of hydrated water, or about 9 per cent.

$$Al_2(OH)_6 - 2H_2O = Al_2O_3.H_2O$$
$$CaO + H_2O = Ca(OH)_2$$
$$\overline{CaO + Al_2(OH)_6 - H_2O = Ca(OH)_2 + Al_2O_3.H_2O}$$

But the actual weight decrease was only about 3 per cent. This difference is due to the formation of calcium hydro-aluminate $xCaO.yAl_2O_3.zH_2O$.

(*d*) In sample No. 254 the actual weight increase is greater than that by calculating the weight increase of free CaO to $Ca(OH)_2$. This difference is also due to the formation of calcium hydro-aluminate.

(*e*) These facts clearly confirm the formation of calcium hydro-aluminate $xCaO.ySiO_2.zH_2O$, containing a large amount of combined water.

(*f*) The value of the molecular ratio of combined lime and soluble alumina is 2.40 in sample No. 232 and 1.98 in No. 254. In sample No. 232 lime combined better with aluminium hydroxide than it did with alumina in No. 254. Thus the calcium hydro-aluminate $xCaO.yAl_2O_3.zH_2O$ will be $2CaO.Al_2O_3.xH_2O$

or $2.5CaO.Al_2O_3.xH_2O$, but the latter hydro-aluminate was proved to be the mixture of the former $2CaO.Al_2O_3.xH_2O$ and $3CaO.Al_2O_3.xH_2O$.

II.—Hydrothermal Combination between Lime and Aluminium Hydroxide.

The results shown in Table II were obtained by changing the heating conditions of pressures and temperatures.

TABLE II.

HYDROTHERMAL COMBINATIONS BETWEEN LIME AND ALUMINIUM HYDROXIDE IN VARIOUS CONDITIONS OF PRESSURES AND TEMPERATURES.

	Sample No. 232.	Sample No. 234.	Sample No. 235.
Mixing proportions ..	CaO 1 mol. $Al_2(OH)_6$ 1 mol.	CaO 1 mol. $Al_2(OH)_6$ 1 mol.	CaO 1 mol. $Al_2(OH)_6$ 1 mol.
Heating conditions ..	5 kg. per sq. cm. 152 to 154 deg. C. 1 day	10 kg. per sq. cm. 180 to 182 deg. C. 1 day	20 kg. per sq. cm. 211 to 213 deg. C. 1 day
(1) Weight increase ..	(−)3.05 per cent.	(−)2.10 per cent.	(−)3.86 per cent.
(2) Loss on ignition ..	23.76 ,,	24.98 ,,	23.21 ,,
(3) Insoluble residue ..	31.41 ,,	31.11 ,,	33.84 ,,
(4) Free lime	3.53 ,,	3.73 ,,	2.38 ,,
(5) Total lime	27.07 ,,	26.84 ,,	27.10 ,,
(6) Combined lime ..	23.54 ,,	23.11 ,,	24.72 ,,
(7) Combination of lime ..	87.0 ,,	86.1 ,,	91.2 ,,
(8) Total alumina	49.02 ,,	47.90 ,,	49.32 ,,
(9) Soluble alumina ..	17.86 ,,	17.19 ,,	15.78 ,,
(10) Combination of alumina	36.4 ,,	35.9 ,,	31.3 ,,
(11). Ratio combined CaO to soluble Al_2O_3 ..	1.32.	1.34	1.57
(12) Molecular ratio combined CaO to soluble Al_2O_3 ..	2.40	2.44	2.85

Samples Nos. 232 and 234 gave nearly equal results. No. 235 gave a larger value of combination of lime and a smaller value of combination of alumina than the former two samples. Thus the heating conditions of pressures and temperatures made the remarkable change between 10 and 20 kg. per square cm. or 180 deg. C. and 212 deg. C. The molecular ratio has nearly the same value in Nos. 232 and 234, but became greater in No. 235, showing the mixture of $2CaO.Al_2O_3.xH_2O$ and $3CaO.Al_2O_3.xH_2O$ as described.

III.—Hydrothermal Combinations between Lime and Alumina.

By the preliminary test in Table I, sample No. 254 was found to produce calcium hydro-aluminate $2CaO.Al_2O_3.xH_2O$. Comparative tests were undertaken on the effect of preliminary calcining temperatures of aluminium hydroxide to alumina on the combination of lime with alumina. Aluminium hydroxide was calcined at 600, 800, and 1,000 deg. C. for three hours, and mixed with newly calcined lime in equimolecular proportion. Samples Nos. 254, 256, and 239 were treated similarly to those already described, and the results are shown in Table III.

These three results gave nearly equal values on all points, probably due to the small mixing amount of lime, and suggest that lime should be used in larger amounts for the formation of calcium hydro-aluminate $xCaO.yAl_2O_3.zH_2O$, in which the content of lime is greater than $2CaO:Al_2O_3$, as is shown later. The molecular ratio of combined CaO to soluble Al_2O_3 is nearly equal to 2.0, showing that the produced calcium hydro-aluminate is perhaps $2CaO.Al_2O_3.xH_2O$.

TABLE III.

HYDROTHERMAL COMBINATIONS BETWEEN LIME AND ALUMINA CALCINED AT VARIOUS TEMPERATURES.

	Sample No. 254.	Sample No. 256.	Sample No. 239.
Mixing proportions ..	CaO 1 mol. Al_2O_3 1 mol. (calcined at 600 deg. C.)	CaO 1 mol. Al_2O_3 1 mol. (calcined at 800 deg. C.)	CaO 1 mol. Al_2O_3 1 mol. (calcined at 1,000 deg. C.)
Heating conditions ..	5 kg. per sq. cm. 152 to 154 deg. C. 1 day	5 kg. per sq. cm. 152 to 154 deg. C. 1 day	5 kg. per sq. cm. 152 to 154 deg. C. 1 day
(1) Weight increase ..	23.14 per cent.	23.35 per cent.	22.65 per cent.
(2) Loss on ignition ..	22.65 ,,	21.87 ,,	22.39 ,,
(3) Insoluble residue ..	32.83 ,,	32.04 ,,	31.36 ,,
(4) Free lime	9.10 ,,	6.99 ,,	5.62 ,,
(5) Total lime	27.40 ,,	27.10 ,,	27.32 ,,
(6) Combined lime ..	18.30 ,,	20.11 ,,	21.70 ,,
(7) Combination of lime ..	66.8 ,,	74.2 ,,	79.4 ,,
(8) Total alumina	49.55 ,,	49.42 ,,	50.34 ,,
(9) Soluble alumina ..	16.72 ,,	17.21 ,,	18.91 ,,
(10) Combination of alumina	33.7 ,,	34.8 ,,	37.6 ,,
(11) Ratio of combined CaO to soluble Al_2O_3 ..	1.09	1.17	1.15
(12) Molecular ratio of combined CaO to soluble Al_2O_3 ..	1.98	2.12	2.09

IV.—Hydrothermal Combinations between Lime and Alumina mixed in Various Proportions.

Four mixtures, namely, (a)$4CaO : Al_2O_3(4 : 1)$, (b)$3CaO : Al_2O_3(3 : 1)$, (c)$2CaO : Al_2O_3(2 : 1)$, and (d)$CaO : Al_2O_3(1 : 1)$ were made from newly-calcined lime and alumina, of which the latter was calcined at 1,000 deg. C. for three

TABLE IV.

HYDROTHERMAL COMBINATIONS BETWEEN LIME AND ALUMINA MIXED IN VARIOUS PROPORTIONS.

	Sample No. 265.	Sample No. 260.	Sample No. 261.	Sample No. 262.
Mixing proportions	CaO 4 mol. Al_2O_3 1 mol.	CaO 3 mol. Al_2O_3 1 mol.	CaO 2 mol. Al_2O_3 1 mol.	CaO 1 mol. Al_2O_3 1 mol.
Heating conditions	10 kg. per sq.cm. 180 to 182 deg.C 1 day	10 kg. per sq.cm. 180 to 182 deg.C 1 day	10 kg. per sq.cm. 180 to 182 deg.C 1 day	10 kg. per sq.cm. 180 to 182 deg.C 1 day
(1) Weight increase ..	37.08 per cent.	34.59 per cent.	30.57 per cent.	16.20 per cent.
(2) Loss on ignition ..	28.03 ,,	25.91 ,,	20.71 ,,	14.18 ,,
(3) Insoluble residue ..	1.14 ,,	6.09 ,,	15.04 ,,	30.99 ,,
(4) Free lime	15.17 ,,	11.92 ,,	10.12 ,,	7.99 ,,
(5) Total lime	49.05 ,,	45.99 ,,	41.40 ,,	30.58 ,,
(6) Combined lime ..	33.88 ,,	34.07 ,,	31.08 ,,	22.59 ,,
(7) Combination of lime	69.1 ,,	74.1 ,,	75.6 ,,	73.9 ,,
(8) Total alumina ..	21.99 ,,	27.55 ,,	37.70 ,,	55.24 ,,
(9) Soluble alumina ..	20.85 ,,	22.46 ,,	22.66 ,,	20.25 ,,
(10) Combination of alumina	94.8 ,,	81.5 ,,	60.1 ,,	36.8 ,,
(11) Ratio of combined CaO to soluble Al_2O_3	1.63	1.52	1.37	1.12
(12) Molecular ratio of combined CaO to soluble Al_2O_3 ..	2.95	2.76	2.49	2.03

hours as in sample No. 239 in Table III. The treatments and analyses were performed similarly to those in the studies previously described, and the results in Table IV were obtained.

In these results the percentage of combination of lime is nearly equal, but that of alumina decreases step by step with the decrease of lime content. The molecular ratio of lime to alumina in No. 265 is nearly equal to 3.0, decreases gradually in Nos. 260 and 261 to between 3.0 and 2.0, and becomes 2.0 in sample No. 262.

V.—Calculation of Rational Formulæ of Calcium Hydro-aluminates Produced by Hydrothermal Synthesis from Mixtures of Lime and Alumina.

In Tables III and IV the value of loss on ignition is the sum of two sorts of combined water, *i.e.* (1)H_2O in Ca $(OH)_2$ and (2) H_2O in $xCaO.yAl_2O_3.zH_2O$. The former, combined water in calcium hydroxide, can be calculated by multiplying the factor 0.321 ($H_2O/CaO = 18.01/56.07 = 0.321$) to the amount of free lime actually obtained. Then the latter, combined water in calcium hydro-aluminates $xCaO.yAl_2O_3.zH_2O$, can be obtained as the difference of total combined water and the water in $Ca(OH)_2$ already calculated.

For the products obtained in Tables III and IV the amount of combined water of calcium hydro-aluminates was calculated by this method and was tabulated with combined lime and soluble alumina in Table V. The amounts of produced calcium hydro-aluminates and their rational formulæ were calculated *i.e.*, $xCaO.yAl_2O_3.zH_2O$ or $x'CaO.Al_2O_3.z'H_2O$ by reducing y to 1). The results are shown in Table V, and some interesting facts are clearly seen.

TABLE V.

AMOUNTS AND RATIONAL FORMULÆ OF CALCIUM HYDRO-ALUMINATES $xCaO . Al_2O_3 . zH_2O$.

No. of Sample.	Combined CaO.	Combined Al_2O_3.	Combined H_2O.	Total amounts of calcium hydro-aluminates.	Molecular Relation.	Rational formulæ of Calcium hydro-aluminates.
	per cent.	per cent.	per cent.	per cent.		
254	18.30	16.72	19.73	54.72	1.99 : 1.00 : 6.68	$2CaO . Al_2O_3 . 7H_2O$ or $2CaO . Al_2O_3 . 6H_2O$
256	20.11	17.21	20.63	57.95	2.12 : 1.00 : 6.78	
239	21.76	18.91	20.59	61.26	2.09 : 1.00 : 6.16	
265	33.88	20.85	23.16	77.89	2.95 : 1.00 : 6.28	$3CaO . Al_2O_3 . 6H_2O$
260	34.07	22.46	22.08	78.61	2.76 : 1.00 : 5.57	Mixed products of $3CaO . Al_2O_3 . 6H_2O$ & $2CaO . Al_2O_3 . 3H_2O$
261	31.08	22.66	17.46	71.20	2.49 : 1.00 : 4.36	
262	22.59	20.25	11.61	54.45	2.03 : 1.00 : 3.24	$2CaO . Al_2O_3 . 3H_2O$

Samples Nos. 254, 256, and 239 gave the formula $2CaO.Al_2O_3.7H_2O$, or $2CaO.Al_2O_3.6H_2O$, but No. 262 gave $2CaO.Al_2O_3.3H_2O$ of smaller amount of combined water. The former, calcium hydro-aluminate $2CaO.Al_2O_3.7H_2O$ or $2CaO.Al_2O_3.6H_2O$, is, perhaps, equal or in close relation with $2CaO.Al_2O_3.7H_2O$ (Allen and Rogers, " Amer. Chem. Journ.," 1900, 24, 304; M. La Fuma, Theses présentés a la Faculte des l'Université de Paris, Paris, 1925), or $2CaO.Al_2O_3.8H_2O$ (K. Koyanagi, " Journ. Soc. Chem. Ind., Japan," 1931, 34, 799; " Review of 19th General Meeting of Assoc. of Japanese Portland Cement Engineers," 1930), which were both obtained by the hydration of alumina cement. This shows that the

equimolecular mixture $CaO : Al_2O_3$ (1 : 1) produces the calcium hydro-aluminate $2CaO.Al_2O_3.7H_2O$ or $2CaO.Al_2O_3.6H_2O$ of higher content of combined water by the hydrothermal heating at lower pressure 5 kg. per sq. cm. and temperature 152 to 154 deg. C., but it produces or changes to $2CaO.Al_2O_3.3H_2O$ of lower content of combined water by the higher pressure 10 kg. per sq. cm. and temperature 180 to 182 deg. C.

From the mixture of highest lime content, $4CaO : Al_2O_3$ (4 : 1), sample No. 265 gave other calcium hydro-aluminate $3CaO.Al_2O_3.6H_2O$, which was reported by T. Thorvaldson and his collaborators from the hydration of calcium aluminates by heating at 150 deg. C and 70 lb. per sq. in. Thorvaldson and his collaborators have reported that $3CaO.Al_2O_3.6H_2O$ is very stable under these conditions, and becomes $3CaO.Al_2O_3.1.5H_2O$ or $3CaO.Al_2O_3.H_2O$ by heating above 300 deg. C. They have also reported some calcium hydro-aluminates of higher content of combined water, as $3CaO.Al_2O_3.8H_2O$, $3CaO.Al_2O_3.10.5H_2O$, $3CaO.Al_2O_3.12H_2O$, etc.

Samples Nos. 260 and 261 obtained from the mixtures $3CaO : Al_2O_3$ (3 : 1) and $2CaO : Al_2O_3$ (2 : 1) gave the mixed calcium hydro-aluminates $3CaO.Al_2O_3.6H_2O$ and $2CaO.Al_2O_3.3H_2O$, in which the values of molecular relations of CaO to Al_2O_3 (2.76 and 2.49) are the intermediate values of 3.0 and 2.0, and those of combined water (5.57 and 4.36) are also the intermediate values of 6.0 and 3.0. Such a mixed product of two calcium hydro-aluminates was already obtained in Tables I and II by the hydrothermal heating of mixtures from lime and aluminium hydroxide as above described.

Summary.

The author has made a series of preliminary studies on hydrothermal synthesis of calcium hydro-aluminates from various mixtures of lime and alumina or aluminium hydroxide by heating under pressure of saturated water vapour in various conditions. Three descriptions of calcium hydro-aluminates, *i.e.* $3CaO.Al_2O_3.6H_2O$, $2CaO.Al_2O_3.7H_2O$, or $2CaO.Al_2O_3.6H_2O$ and $2CaO.Al_2O_3.3H_2O$, were found provisionally by the calculation of their rational formulæ from analytical data. The first, $3CaO.Al_2O_3.6H_2O$, coincides with that obtained by T. Thorvaldson and his collaborators in the hydration of tricalcium aluminate. The hydro-aluminate $2CaO.Al_2O_3.7H_2O$, $2CaO.Al_2O_3.6H_2O$, is obtained under lower heating conditions than $2CaO.Al_2O_3.3H_2O$, and changes to the latter by heating at higher pressure and temperature.

These calcium hydro-aluminates are not yet produced in a pure state; they must be obtained in a pure state and be further studied. The author hopes to study the hydrothermal synthesis of calcium hydro-aluminates in parallel to that of calcium hydro-silicates, and to give later the results of further studies.

In conclusion, the author wishes to express his thanks to Professor Dr. W. Eitel, Director of the Kaiser Wilhelm-Institut für Silikatforschung, Berlin-Dahlem, Germany, for his kind guidance throughout the work.

(Research Institute of Silicate Industry, Department of Applied Chemistry, Faculty of Engineering, Tokio Imperial University, Japan.)

Proposed New Cement Plant in India.

The U.S.A. Trade Commissioner at Calcutta reports that the erection of a cement plant at Dewarkhand, India, under the management of National Cement Mines and Industries, Ltd., having an initial capacity of 50,000 long tons annually, as well as a factory for the production of 45,000 long tons of unslaked lime, is under consideration.

A Damp Cupboard for Cement Testing.

THE conditions under which cement briquettes and other test-pieces are stored during the curing period before testing may have a considerable influence upon the results of such tests, and most specifications for Portland cement require that briquettes for tensile tests shall be stored in a moist atmosphere during the first twenty-four hours after gauging. In the British Standard Specification for Portland Cement (1931) clause 11 states that the briquettes "shall be kept in an atmosphere of at least 90 per cent. relative humidity for twenty-four hours after gauging," and Clause 12 stipulates that the test-block used for the determination of setting time "shall be kept during the whole time of the test in an atmosphere of at least 90 per cent. relative humidity and away from draughts." Some foreign specifications, notably that adopted in the Argentine, require that the first 24-hours storage of the briquettes, the determination of setting time,

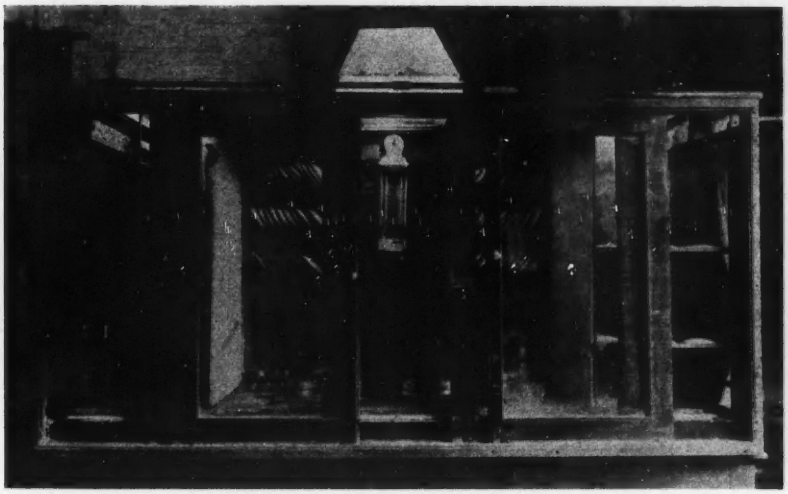


Fig. 1.

and the storage of test-pieces for "constancy of volume," shall be carried out in "an atmosphere saturated with moisture" within specified temperature limits. In the U.S.A. the American Society for Testing Materials, in the last revision of their Standard Specification (1930), require that the relative humidity of the moist closet used for the storage of all test specimens should be not less than 90 per cent.

These provisions can only be satisfactorily met by some form of humidity chamber, and in view of the new requirements of the British Standard Specification a description of a chamber which has given satisfaction at the Imperial Institute over a long period may be of interest to those concerned with cement testing. This chamber (Fig. 1) was installed in 1917, after the Imperial Institute had been appointed by the Board of Trade to be the official station for the

AN IMPROVED DAMP CUPBOARD FOR CEMENT TESTING

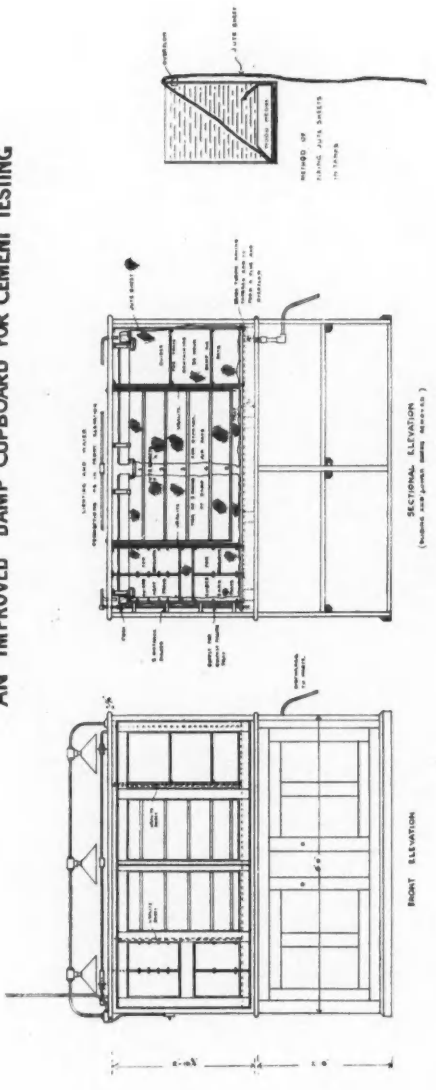


Fig. 2.

testing and certification of consignments of British cement intended for export, and was made from designs prepared by Mr. A. T. Faircloth, a member of the Imperial Institute Staff. It is possible to maintain a saturated atmosphere in this cupboard with the minimum of attention, and even when the sliding doors are periodically opened (as is necessary during the determination of setting time) the relative humidity as shown by the wet-and-dry bulb hygrometer rarely falls below 90 per cent.

The construction of the cupboard will be seen from Fig. 2. It consists of two portions, the lower being divided into two storage cupboards, whilst the top portion which forms the damp chamber is separated into three compartments illuminated by top lighting from outside. The centre compartment is twice the length of those on each side, from which it is separated by sheets of asbestos-cement.

Each of the compartments can be closed by glazed sliding doors, either of which can be opened to the exterior air without affecting the humidity of the atmosphere in the others. This arrangement enables the central compartment to be used for setting-time tests while those at each end are in use for the storage of tensile briquettes or for the "damp air" and "water" pats which the Argentine specification requires as the test for "constancy of volume." The sliding doors prevent draughts, the exclusion of which is of vital importance when neat cement pats (especially those containing a high percentage of water) are under test for "constancy of volume."

In order to obtain the necessary humidity conditions the sides and back of the chamber are loosely covered with jute sheets which dip into water tanks fixed around the top of the chambers. By this means water travels by capillary attraction slowly down the jute, and by reason of its evaporation in transit produces a saturated atmosphere. The lower ends of the jute sheets dip into a galvanised-iron tray in the bottom of the chamber. The tanks containing the water are of galvanised iron and supported upon iron brackets along the back and at each end of the chamber. Those at the back are each 2 ft. 6 in. long by $2\frac{1}{4}$ in. deep by $1\frac{1}{2}$ in. in width, while the end tanks are only 2 ft. 2 in. in length. Each tank communicates with its neighbour by means of a short lead pipe in the bottom. Water is conveyed to them by pipes placed outside the top of the cupboard and connected with a 50-gallon tank filled with water, the temperature of which is normally maintained at the standard testing-room temperature but which can be adjusted should occasion arise.

The tray which receives the water brought down by the jute sheets is fitted with an overflow so arranged that a depth of about 3 in. of water is kept constantly in the tray, any excess of water being carried down the overflow and outside the cupboard to the waste. Wood frames covered with $\frac{1}{4}$ in.-mesh brass wire gauze rest on the top of the tray and form a false bottom to the chamber. Overflow pipes are provided for each of the small tanks which discharge on to the jute sheets.

The compartment at the left end of the chamber is fitted with guides made from $\frac{3}{4}$ in. by $\frac{1}{8}$ in. strip iron in which slide twenty iron trays having a total capacity of 120 tensile strength briquette moulds. The compartment on the right contains similar iron guides accommodating trays upon which are placed the neat-cement pats under test for "constancy of volume." All the ironwork is treated with a graphite waterproof paint, which is scraped off and renewed when necessary, usually every two or three years.

Hardening of Portland Cement.

SOME NEW EXPERIMENTS.

By K. KOYANAGI.

IN CEMENT AND CEMENT MANUFACTURE for October, 1931, p. 115, appeared an article by Mr. F. Tippmann on "The Hardening of Portland Cement," in which the author disposes of the hydration of pure calcium oxide as follows:

(1) Whether pure calcium oxide is treated with the normal quantity or with an excess of water, it forms an exclusively amorphous and in part colloidal hydrate. So long as the saturated $Ca(OH)_2$ solution is in contact with the amorphous hydrate as the basic phase, no crystalline hydrate is formed.

(2) Amorphous calcium hydrate can be converted into a form capable of crystallisation by means of an inciter of crystallisation. Calcium sulphate is such

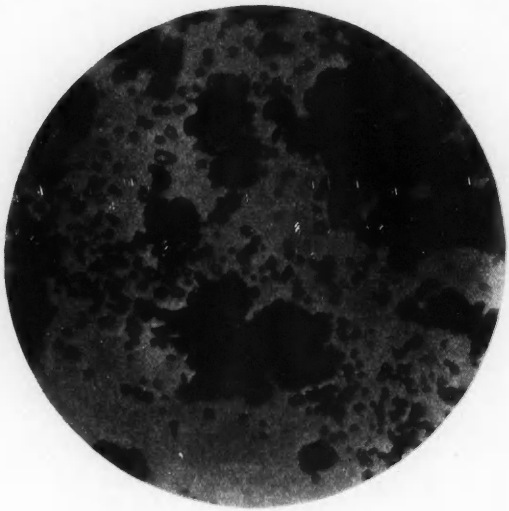


Fig. 1.

Magnified 280 times.

a crystallising agent; to a much less degree gelatinous silica also has this property. The gypsum solution prevents the formation of amorphous hydrate on slaking and catalytically causes a prolific separation of crystalline calcium hydrate.

(3) When calcium oxide is slaked with a very dilute solution of gypsum crystalline calcium hydrate is produced in the form of very fine needles, which are identical in form and optical properties with the crystals—generally supposed to be monocalcium hydrosilicate needles—which are formed in microscopic preparations of cement in great excess of water.

In his reply to Mr. Tippmann (in the January, 1932, number of this Journal) Professor Kühl gives the following explanation of these phenomena: The slaking of lime with water is an extremely energetic reaction. Supersaturation very rapidly ensues, and this prevents the formation of well-defined crystals, as has been shown by P. P. von Weimarn. A colloidal system is thus easily formed,

of which the disperse phase (in accordance with Ostwald's law of stages) is at first unstable. Such preliminary deposits are transformed later—although possibly very slowly—into the stable state. If the lime is slaked with a salt solution (gypsum solution) instead of with water the specific action of the salt becomes apparent. The stability conditions of the disperse phase are greatly modified by the dissolved salt and its ions. It is therefore not surprising if the tendency to crystal formation is greater on slaking with gypsum water than with pure water.

Since Tippmann's observations are very noteworthy, and to some extent surprising, I have carried out certain experiments with the object of testing them. The calcium oxide used in these experiments was prepared by igniting Kahlbaum calcium carbonate for one hour in an electric furnace at 1,100 deg. C. The resulting lime was mixed, respectively, with distilled water, saturated gypsum water, and gypsum water of a wide range of concentrations, under the most diverse conditions, and the experiments were followed under the microscope over a long period.

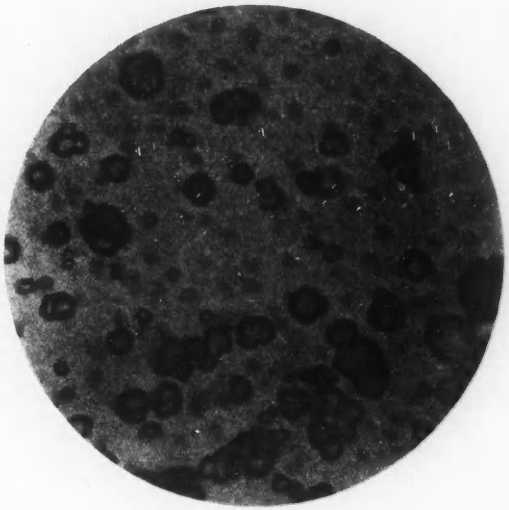


Fig. 2.
Magnified 1,300 times.

In the preparations of lime with pure distilled water, in addition to the bulk of amorphous hydrate, there appeared after some hours a new, minute formation (Fig. 1) which was scattered about the open spaces of the slide. This new material has the appearance of an amorphous or gel mass, but under greater magnification it was proved to consist of imperfectly formed hexagonal crystals (Fig. 2). This new substance is luminous between crossed Nicols, so that it is undoubtedly of a crystalline nature.

In the preparations of lime with gypsum solution, well-formed hexagonal crystals of calcium hydrate were seen (Fig. 3). At greater magnification, however, a considerable quantity of amorphous hydrate was found mixed with the crystalline hydrate (Fig. 4).

The results of these experiments are thus somewhat different from those of Tippmann. Crystalline calcium hydrate is produced when lime is slaked both

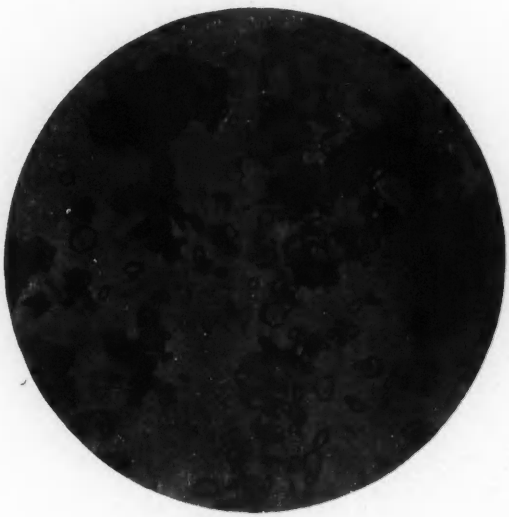


Fig. 3.
Magnified 240 times.

with pure water and with gypsum solution. The only difference between the two cases is that in the former the hydrate crystals are extremely minute and

Fig. 4.
Magnified 450 times.

imperfectly formed, while in the latter they are much larger and more numerous and are perfectly formed.

With the object of following these phenomena more closely, the author has investigated the solubility of lime in water and gypsum solution.

Tippmann is of opinion that gypsum water is capable of dissolving much more calcium hydrate than water. Professor Kühl, on the contrary, believes the opposite to be true. According to the law of mass action (Nernst's law) the solubility of an electrolyte is lowered by the addition of a second electrolyte with a common ion.

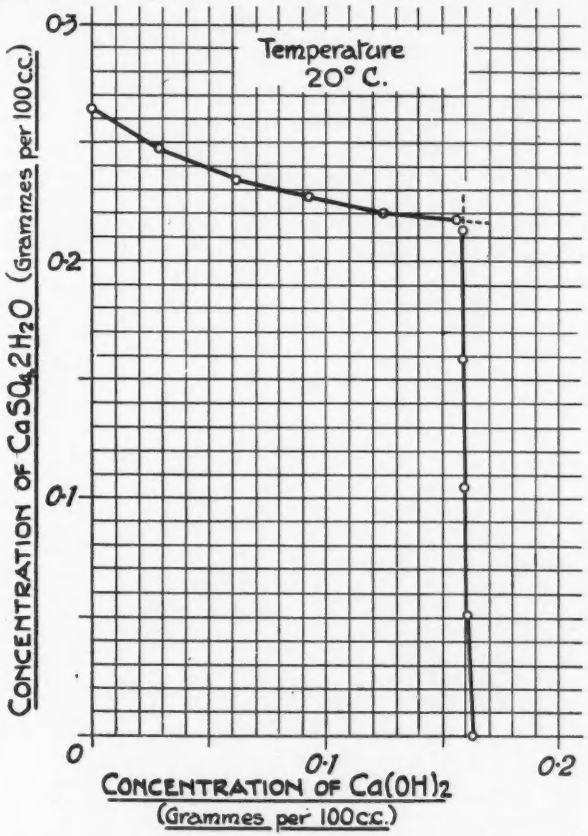


Fig. 5.

The writer determined the solubility of gypsum in lime water of various concentrations, and of calcium hydrate in gypsum water of a range of concentrations. Fig. 5 shows the isothermal solubility curves, and it will be observed from these curves that the solubility of calcium hydrate is somewhat less in gypsum solution than in water, while the solubility of gypsum is somewhat less in lime water than in pure water; this is exactly what is required by the Nernst law.

On slaking calcium oxide in water and gypsum water the conditions are somewhat different. The author shook up pure CaO with water and with gypsum

water respectively for varying times, and determined the solubility of the lime. The amount of CaO dissolved in the gypsum water was obtained by subtracting the CaO combined with SO_3 from the total CaO. The solubility curves, which are reproduced in Fig. 6, show that on slaking calcium oxide with both pure water and gypsum water supersaturation very rapidly ensues, and that the solubility of CaO in gypsum water is higher in the first small interval of time than the solubility in pure distilled water. The unstable phase is later slowly transformed to the stable state, and after about two hours both systems attain approximate equilibrium, so that the solubility of CaO in gypsum water is uniformly lower than that in pure water. It is thus seen that on slaking lime with gypsum water much more lime passes into solution, and is later thrown down, than when lime is slaked with pure water.

These facts offer a clear explanation of the more prolific crystal formation on slaking lime with gypsum water. Tippmann's explanation by means of the word "catalyst" cannot be understood without further elucidation.

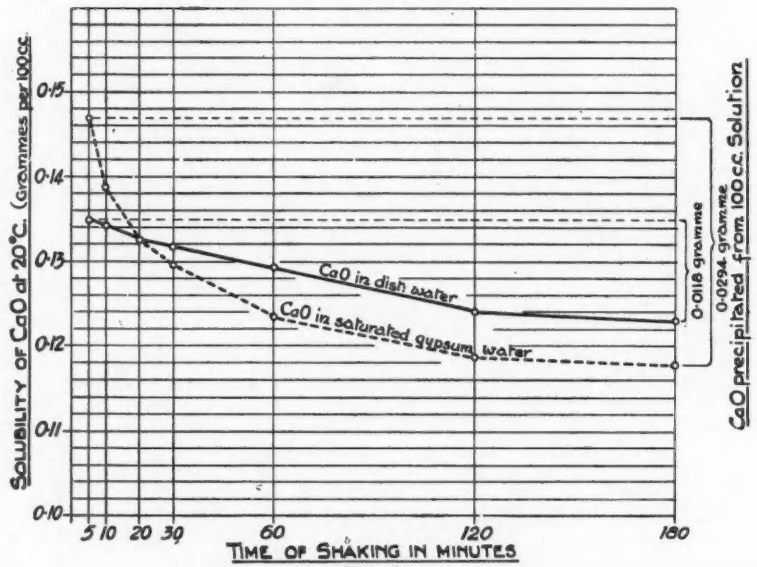


Fig. 6.

The third and most notable observation of Tippmann, *viz.*, that on slaking lime with very dilute gypsum water a crystalline modification of calcium hydrate consisting of fine needles is formed, was also investigated with the greatest care by the writer, but in all cases with negative result. The writer has studied the hydration of hydraulic cements for many years, but has never found calcium hydrate to crystallise in the form of fine needles. He has recently established [1] the chemical composition and optical properties of the fine needle crystals which are seen when preparations of cement in excess of water are studied microscopically and which are generally known as calcium hydrosilicate. They are certainly not calcium hydrate, but are actually calcium sulphoaluminate of the composition $3CaO.Al_2O_3.3CaSO_4.32.6H_2O$.

[1] K. Koyanagi, *Zement*, Vol. 20, No. 48, 1931.

Heat Economy in the Cement Industry.—IV.

By Dr. HANS BUSSMEYER.

Power Consumption and Overall Fuel Consumption of Cement Works.

ALTHOUGH the present tendency is to concentrate the generation of electricity in a few particularly suitable districts, United States experience with waste-heat boilers in conjunction with the rotary kiln has opened the possibility of reducing production costs by installing separate power plants in individual cement works. We must therefore consider (1) the general power consumption of cement works, and (2) the recovery of the waste heat of the rotary kiln.

The literature dealing with power consumption in cement manufacture contains such diverse results and is so uncertain in its hypotheses that it is difficult to draw any general conclusions. In the first place two methods of preparation

TABLE XIX.

WET PROCESS. LIMESTONE AND MARL CRUSHED AND GROUND TOGETHER.

Method of Working.		Continuous.		Closed down on Sunday.			Average.
Shift No.		I.	II, III.	I.	II, III.	Sunday.	
Preliminary crushing	H.P.h.	6.8	—	6.8	—	—	2.3
Raw mill (to 10 per cent. on 180 sieve)	„	38.4	38.4	44.8	44.8	—	38.4
Slurry transport	„	3.7	3.7	3.9	3.9	2.8	3.7
Rotary kiln	„	8.4	8.4	8.4	8.4	8.4	8.4
Cement mill (to 5 per cent. on 180 sieve)	„	38.0	38.0	44.4	44.4	—	38.0
Clinker and cement transport	„	5.4	5.4	6.1	6.1	1.4	5.4
Packing	„	4.0	—	4.0	—	—	1.3
Additional plant	„	3.0	2.5	3.0	2.5	1.5	2.6
Total power required by plant	„	109.5	98.2	123.5	112.2	14.1	101.9
Losses between plant and generator	„	21.9	19.6	24.7	22.4	2.8	20.4
Load on generator, exclusive of coal grinding	kWh.	131.4	117.8	148.2	134.6	16.9	122.3
		96.7	86.7	109.1	99.1	12.4	90.0
Coal consumption: Kiln	kg.	240.0	240.0	240.0	240.0	240.0	240.0
Coal drier ($b'=5$ per cent.)	„	2.6	2.6	2.6	2.6	2.6	2.6
Total coal consumption of cement plant	„	242.6	242.6	242.6	242.6	242.6	242.6
Load on generator, including coal grinding	kWh.	106.4	96.4	118.8	108.8	22.1	99.7
Coal consumption of works power plant	kg.	84.2	76.3	94.0	86.0	17.5	79.0
Cement plant, plus power plant:—							
Total coal consumption	„	326.8	318.9	336.6	328.6	259.1	321.6
Total power output	kWh.	109.8	99.4	122.4	112.2	22.8	102.8

must be considered, *viz.*, the wet and the dry processes. The first has the advantage of greater simplicity in the plant preceding the rotary kiln, the power consumed in transporting the materials is less than in the wet process, and the power required for grinding is somewhat lower than for wet grinding to the same fineness. The physical properties of raw materials have a very important influence, which chiefly affects the power required for preliminary crushing. Limestone and hard marl are best prepared in hammer crushers. Soft materials, especially chalk and clay, are best dealt with in wash-mills, in which they are so finely divided that in many cases no further comminution is necessary. In general, different raw materials vary greatly in their behaviour in both the wet and the dry mill, and may give rise to undesirable results when a high degree of fineness is required.

Taking the power consumption per 1000 kg. clinker as a unit, this figure falls as the production of a cement works increases. For comparative purposes daily

output should only be compared with daily output, and not with yearly output. Naturally the general disposition of a works has a great influence on power consumption.

Finally the power consumption is increased by complication of the plant arising from such factors as the utmost possible exclusion of manual labour, the high requirements as regards safety and smoothness of running, the necessity for extreme fineness of grinding and for dust removal, and the simultaneous production of several qualities of cement in a relatively small works. These factors render it impossible directly to compare the figures for the power consumption of different cement works.

It is impossible in these articles to investigate the individual effects of all the possible variables on power consumption, and we must limit ourselves to a number of typical cases of which the data are given in Tables XIX to XXV. Each of the plants considered consists of two rotary kilns and has a total clinker

TABLE XX.

WET PROCESS. LIMESTONE AND PLASTIC CLAY.

Method of Working.		Continuous.		Closed down on Sunday.			Average
Shift No.		I.	II, III.	I.	II, III.	Sunday.	
Preliminary crushing	H.P.h.	8.7	—	8.7	—	—	2.9
Raw mill (to 10 per cent. on 180 sieve) ..	„	30.0	30.0	35.0	35.0	—	30.0
Slurry transport	„	5.2	5.2	5.8	5.4	3.2	5.2
Rotary kiln	„	8.4	8.4	8.4	8.4	8.4	8.4
Cement mill (to 5 per cent. on 180 sieve)	„	38.0	38.0	44.4	44.4	—	38.0
Clinker and cement transport	„	5.4	5.4	6.1	6.1	1.4	5.4
Packing	„	4.0	—	4.0	—	—	1.3
Dust extracting plant	„	1.8	1.8	2.1	2.1	—	1.8
Additional plant	„	3.0	2.5	3.0	2.5	1.5	2.6
Total power required by plant	„	104.5	91.3	117.5	103.9	14.5	95.6
Losses between plant and generator ..	„	20.9	18.3	23.5	20.8	2.9	19.1
Load on generator, exclusive of coal grinding	„ kWh.	125.4 92.3	109.6 80.7	141.0 103.8	124.7 91.8	17.4 12.8	114.7 84.4
Coal consumption :—							
Kiln	kg.	240.0	240.0	240.0	240.0	240.0	240.0
Coal drier (b' = 5 per cent.)	„	2.6	2.6	2.6	2.6	2.6	2.6
Total coal consumption of cement plant	„	242.6	242.6	242.6	242.6	242.6	242.6
Load on generator, including coal grinding	kWh.	102.0	90.4	113.5	101.5	22.5	94.1
Coal consumption of works power plant ..	kg.	80.6	71.5	89.8	80.4	17.8	74.5
Cement plant, plus power plant :—							
Total coal consumption	„	323.2	314.1	332.4	323.0	260.4	316.1
Total power output	kWh.	105.2	93.2	117.0	104.6	23.2	96.9

output of 400 to 500 tons per 24 hours. There is, however, one exception, Table XXV, which deals with a single-kiln plant producing blast-furnace cement; the daily output is 200 to 250 tons clinker, which is mixed in the proportions 30 parts clinker to 70 parts slag to give 650 to 800 tons of cement in 24 hours.

A distinction is made between continuous running in which work is carried on throughout Sunday except for the crushing or wash-milling (which must be adapted to the working of the quarries) and the cement packing, and discontinuous running in which only the kiln is working on Sunday. The tables are calculated on the three-shift system, in which crushing, wash-milling and cement packing are only carried on during the first shift. There is thus a heavier load on the power plant during the first shift, while during the second and third the load is equal and lighter.

All the data relate to 1000 kg. clinker. For the Portland cements, neglecting the small gypsum addition, the figures may be assumed to apply to 1000 kg. cement. This is not so, however, for the slag cements (Tables XXIV and XXV), and for these the data per 1000 kg. cement (neglecting gypsum) are given in addition to those for 1000 kg. clinker.

TABLE XXI.

WET PROCESS. CHALK AND CLAY FIRST WASH-MILLED AND THEN TUBE-MILLED.

Method of Working.	Continuous.		Closed down on Sunday.			Average.
Shift No.	I.	II, III.	I.	II, III.	Sunday.	
Wash mills .. .. H.P.h.	15.7	—	15.7	—	—	5.2
Raw tube-mills .. .. ,,	20.0	20.0	23.4	23.4	—	20.0
Slurry transport .. .. ,,	7.6	4.3	8.5	4.6	2.5	5.4
Rotary kiln .. .. ,,	8.4	8.4	8.4	8.4	8.4	8.4
Clinker and cement transport .. .. ,,	5.4	5.4	6.1	6.1	1.4	5.4
Cement mill (to 5 per cent. on 180 sieve) .. ,,	38.0	38.0	44.4	44.4	—	38.0
Packing .. .. ,,	4.0	—	4.0	—	—	1.3
Dust extraction plant .. .. .. ,,	1.8	1.8	2.1	2.1	—	1.8
Additional plant .. .. ,,	3.0	2.5	3.0	2.5	1.5	2.6
Total power required by plant .. .. ,,	103.9	80.4	115.6	91.5	13.8	88.1
Losses between plant and generator .. ,,	20.8	16.1	23.1	18.3	2.8	17.6
Load on generator, exclusive of coal grinding .. .. ,, kWh.	124.7 91.3	96.5 71.0	138.7 101.0	109.8 80.8	16.6 12.2	105.7 77.8
Coal consumption :—						
Kiln .. .. kg.	240.0	240.0	240.0	240.0	240.0	240.0
Coal drier ($b'=5$ per cent.) .. .. ,,	2.6	2.6	2.6	2.6	2.6	2.6
Total coal consumption of cement plant ,,	242.6	242.6	242.6	242.6	242.6	242.6
Load on generator, including coal grinding kWh.	101.0	80.7	110.7	90.5	21.9	87.5
Coal consumption of works power plant .. kg.	79.9	63.8	87.5	71.6	17.3	69.2
Cement plant, plus power plant :—						
Total coal consumption .. .. ,,	322.5	306.4	329.1	314.2	259.9	311.6
Total power output .. .. .. kWh.	104.1	83.2	114.1	93.3	22.6	90.2

TABLE XXII.

DRY PROCESS. SHAFT KILN. LIMESTONE AND MARL CRUSHED AND GROUND TOGETHER.

Method of Working.	Continuous.		Closed down on Sunday.			Average.
Shift No.	I.	II, III.	I.	II, III.	Sunday.	
Preliminary crushing .. .. .. H.P.h.	6.8	—	6.8	—	—	2.3
Drier .. .. ,,	2.0	2.0	2.3	2.3	—	2.0
Raw mill (10 per cent. on 180 sieve) .. ,,	40.0	40.0	46.7	46.7	—	40.0
Shaft kiln .. .. ,,	17.5	14.5	14.5	14.5	14.5	14.5
Cement mill (5 per cent. on 180 sieve) .. ,,	30.0	30.0	35.0	35.0	—	30.0
Raw meal handling .. .. .. ,,	7.5	7.5	8.4	8.4	2.5	7.5
Clinker and cement transport .. .. ,,	5.4	5.4	6.1	6.1	1.4	5.4
Packing .. .. ,,	4.0	—	4.0	—	—	1.3
Dust extraction .. .. ,,	4.6	4.6	5.3	5.3	—	4.6
Additional plant .. .. ,,	3.0	2.5	3.0	2.5	1.5	2.6
Total power required by plant .. .. ,,	117.8	106.5	132.1	120.8	19.9	110.2
Losses between plant and generator .. ,,	23.6	21.3	26.4	24.2	4.0	22.0
Load on generator .. .. .. ,,	141.4	127.8	158.5	145.0	23.9	132.2
Load on generator .. .. .. kWh.	104.1	94.1	117.0	106.7	17.6	97.3
Coal consumption :—						
Drier ($b'=12$ per cent.) .. .. kg.	30.0	30.0	35.0	35.0	—	30.0
Shaft kiln .. .. ,,	160.0	160.0	160.0	160.0	160.0	160.0
Total coal consumption of cement plant .. ,,	190.0	190.0	195.0	195.0	160.0	190.0
Coal consumption of power plant .. ,,	82.4	74.5	92.5	84.4	13.9	77.0
Cement plant, plus power plant :—						
Total coal consumption .. .. kg.	272.4	264.5	287.5	279.4	173.9	267.0
Total power output .. .. .. kWh.	107.3	97.0	121.0	113.0	18.1	100.3

The tables contain the power consumption figures for all the important units of a cement works. The transport of the raw materials from the quarry to the works is not included, since this only affects the power plant when wire-cable traction is used. Similarly the working of the quarry is not considered. The heading " Additional plant " includes repair shops, water supply and lighting.

To the power consumption of the machine units must be added the loss between these and the power plant. At the present day it is only necessary to consider electrical transmission, using either individual motors or motors driving groups of plant. The highly efficient gearing now adopted by the cement industry enables rapidly running motors to be used, resulting in higher efficiency and improved cos θ. In recent years, group drive is being more and more replaced by individual motors with intermediate gearing, and transmission losses between the motors and the plant are relatively unimportant.

Of greater importance, however, are the losses in the motors and in the cables. In the cement industry all motors must be able to cope with occasional heavy

TABLE XXIII.

DRY PROCESS ROTARY KILN. LIMESTONE AND MARL CRUSHED AND GROUND TOGETHER.

Method of Working.		Continuous.		Closed down on Sunday.			Average.
Shift No.		I.	II, III.	I.	II, III.	Sunday.	
Preliminary crushing	H.P.h.	6.8	—	6.8	—	—	2.3
Drier	„	2.0	2.0	2.3	2.3	—	2.0
Raw mill (10 per cent. on 180 sieve)	„	40.0	40.0	46.7	46.7	—	40.0
Raw meal handling	„	7.5	7.5	8.4	8.4	2.5	7.5
Rotary kiln	„	8.4	8.4	8.4	8.4	8.4	8.4
Cement mill (5 per cent. on 180 sieve)	„	38.0	38.0	44.4	44.4	—	38.0
Clinker and cement transport	„	5.4	5.4	6.1	6.1	1.4	5.4
Packing	„	4.0	—	4.0	—	—	1.3
Dust extraction	„	4.6	4.6	5.3	5.3	—	4.6
Additional plant	„	3.0	2.5	3.0	2.5	1.5	2.6
Total power required by plant	„	119.7	108.4	134.4	125.1	13.8	112.1
Losses between plant and generator	„	23.9	21.7	26.9	25.0	2.8	22.4
Load on generator, exclusive of coal grinding	kWh.	143.6 105.7	131.1 96.5	161.3 118.7	150.1 110.5	16.6 12.2	134.5 99.0
Coal consumption :—							
Raw material drier (b' = 12 per cent.)	kg.	30.0	30.0	35.0	35.0	—	30.0
Rotary kiln	„	210.0	210.0	210.0	210.0	210.0	210.0
Coal drier (b' = 5 per cent.)	„	2.2	2.2	2.2	2.2	2.2	2.2
Total coal consumption of cement plant	„	242.2	242.2	247.2	247.2	212.2	242.2
Load on generator, including coal grinding	kWh.	115.4	106.2	128.6	120.4	20.7	108.7
Coal consumption of power plant	kg.	91.4	84.0	101.8	95.2	16.4	85.9
Cement plant, plus power plant :—							
Total coal consumption	kg.	333.6	326.2	349.0	342.4	228.6	328.1
Total power output	kWh.	119.0	109.5	132.6	124.1	21.3	112.1

increases over the average load, so that under normal conditions they are not working on the most favourable part of the efficiency curve. The cable losses may be taken as 3 per cent. of the current at the generator terminals, the motor losses as 12 per cent., and the transmission losses as 1.5 per cent. The efficiencies must be multiplied, giving a value for the overall efficiency of the electrical power transmission from the generator to the machines equal to $0.98 \times 0.88 \times 0.98$, or 0.84; *i.e.*, 19 per cent. must be added to the power requirements of the machinery to obtain the current that must be developed at the generator terminals. A value of 20 per cent. is added in the tables.

The values thus obtained in Continental horse-power hours* or kilowatt hours per 1000 kg. clinker or cement do not include the power consumed in grinding the coal. They apply, however, to works using liquid or gaseous fuel

* 1 Continental H.P. = 0.986 British H.P.

and obtaining current from an outside generating station. In such cases the works' generating plant is represented by the transformers converting the high voltage supply to the working voltage.

The following figures give the power required to produce 1000 kg. powdered coal ground to 8 to 10 per cent. residue on the 180 (per inch) sieve:

	H.P. Hours.
Coal drying	3.0
Grinding	34.0
Dust extraction plant	1.8
Conveyers, etc.	6.5
Power required at the plant	45.3
Losses from generator to plant	9.1
Load at generator terminals	54.4=40.0 kW-hours.

In constructing new plants the following average values may be taken for the heat or fuel requirements of electric generating plants of the sizes useful in cement works: For turbo-generators at three-quarter load, with steam at 18 atmospheres (265 lb. per sq. in.) pressure and 330 deg. C. (626 deg. F.), a steam consumption of 5.2 kg. (11.5 lb.) per kWh at the generator terminals

TABLE XXIV.

DRY PROCESS. IRON-PORTLAND CEMENT. 70 PARTS CLINKER TO 30 PARTS SLAG. 1000 KG. CLINKER=1,450 KG. CEMENT=1,350 KG. RAW MATERIAL=850 KG. LIMESTONE+(500+430) KG. SLAG.

Method of Working.	Continuous.		Closed down on Sunday.			
Shift No.	I.	II, III.	I.	II, III.	Sunday.	Average.
Crushing limestone H.P.h.	3.6	—	3.6	—	—	1.2
Drier „	2.2	2.2	2.6	2.6	—	2.2
Raw mill (10 per cent. on 180 sieve) „	36.5	36.5	42.5	42.5	—	36.5
Raw meal handling „	6.3	6.3	7.0	7.0	2.1	6.3
Rotary kiln „	8.4	8.4	8.4	8.4	8.4	8.4
Cement mill (5 per cent. on 180 sieve) „	60.0	60.0	70.0	70.0	—	60.0
Clinker and cement transport „	6.7	6.7	7.6	7.6	1.4	6.7
Packing „	5.7	—	5.7	—	—	1.9
Dust extraction „	4.8	4.8	5.6	5.6	—	4.8
Additional plant „	3.0	2.5	3.0	2.5	1.5	2.6
Total power required by plant „	137.2	127.4	156.0	146.2	13.4	130.6
Losses between plant and generator „	27.4	25.5	31.2	29.2	2.7	26.1
Load on generator, exclusive of coal grinding :—						
Per 1,000 kg. clinker „	164.6	152.9	187.2	175.4	16.1	156.7
Per 1,000 kg. clinker kWh.	121.1	112.5	137.8	129.1	11.8	115.2
Per 1,000 kg. cement „	84.8	78.8	96.5	90.4	8.3	80.7
Coal consumption, exclusive of power plant :—						
Limestone drier (b'=5 per cent.) kg.	8.5	8.5	10.0	10.0	—	8.5
Slag drier (b'=30 per cent.) „	50.0	50.0	68.0	68.0	—	50.0
Rotary kiln „	180.0	180.0	180.0	180.0	180.0	180.0
Coal drier (b'=5 per cent.) „	2.0	2.0	2.0	2.0	2.0	2.0
Total per 1,000 kg. clinker „	240.5	240.5	260.0	260.0	182.0	240.5
Total per 1,000 kg. cement „	168.0	168.0	182.0	182.0	127.4	168.0
Load on generator, including coal grinding						
Per 1,000 kg. clinker kWh.	130.7	122.1	148.2	139.5	12.5	124.9
Per 1,000 kg. cement „	91.8	85.8	103.7	97.7	8.8	87.7
Requirements of power plant referred to clinker :—						
Coal consumption kg.	103.9	97.0	117.2	110.5	9.9	99.2
Power consumption kWh.	4.1	3.8	4.3	4.3	0.4	3.9
Totals, including power plant :—						
Coal per 1,000 kg. clinker kg.	344.4	337.5	377.2	370.5	191.9	339.7
Coal per 1,000 kg. cement „	240.0	236.0	264.0	259.0	134.0	238.0
Power per 1,000 kg. clinker kWh.	135.2	126.3	152.8	143.8	12.9	129.2
Power per 1,000 kg. cement „	94.6	88.4	107.0	100.7	9.0	90.4

may be assumed. To this must be added 15 per cent. for losses in the generating plant, giving 6.0 kg. (13.2 lb.) per kWh. Taking a 2-atmosphere (29.4 lb.) fall in pressure and a 20 deg. C. (36 deg. F.) fall in temperature, the values required in the boiler are 20 atmospheres (294 lb.) and 350 deg. C. (662 deg. F.). This is equivalent to 720 kcal. per 1 kg. (1,300 B.T.U. per 1 lb.) steam in the boiler with feed water at 20 deg. C. (68 deg. F.). Taking the overall efficiency of the boiler plant as 76 per cent., 950 kcal. per 1 kg. (1,700 B.T.U. per lb.) of steam are required. That is, for each kilowatt-hour taken from the generator terminals, 5,700 kcal. (22,600 B.T.U.) or 0.76 kg. (1.68 lb.) standard

TABLE XXV.

DRY PROCESS. BLAST-FURNACE CEMENT. 30 PARTS CLINKER TO 70 PARTS SLAG. 1,000 KG. CLINKER=3,340 KG. CEMENT=1,350 KG. RAW MATERIAL=850 KG. LIMESTONE=(500+2,340) KG. SLAG.

Method of Working.	Continuous.		Closed down on Sunday.			Average.
Shift No.	I.	II, III.	I.	II, III.	Sunday.	
Crushing limestone .. .. .. H.P.h.	3.6	—	3.6	—	—	1.2
Drier .. .. „	4.0	4.0	4.7	4.7	—	4.0
Raw mill (10 per cent. on 180 sieve) .. „	36.5	36.5	42.5	42.5	—	36.5
Raw meal handling .. .. .. „	6.3	6.3	7.0	7.0	2.1	6.3
Rotary kiln .. .. „	8.4	8.4	8.4	8.4	8.4	8.4
Cement mill (5 per cent. on 180 sieve) .. „	153.4	153.5	179.0	179.0	—	153.5
Clinker and cement transport .. .. „	16.6	16.6	19.1	19.1	1.4	16.6
Packing .. .. „	13.2	—	13.2	—	—	4.4
Dust extraction .. .. „	8.1	8.1	9.4	9.4	—	8.1
Additional plant .. .. „	3.0	2.5	3.0	2.5	1.5	2.6
Total power required by plant .. .. „	253.2	235.9	289.9	272.6	13.4	241.6
Losses between plant and generator .. „	50.6	47.2	58.0	54.5	3.7	48.3
Load on generator, exclusive of coal grinding :—						
Per 1,000 kg. clinker.. .. .. „	303.8	283.1	347.9	327.1	17.1	289.9
Per 1,000 kg. clinker.. .. .. kWh.	223.6	208.4	256.1	240.7	12.6	213.4
Per 1,000 kg. cement .. .. „	67.1	62.5	76.8	72.2	3.8	64.0
Coal consumption, exclusive of power plant :—						
Limestone drier (b'=5 per cent.) .. kg.	8.5	8.5	10.0	10.0	—	8.5
Slag drier (b'=30 per cent.) .. „	153.0	153.0	178.0	178.0	—	153.0
Rotary kiln .. .. „	180.0	180.0	180.0	180.0	180.0	180.0
Coal drier (b'=5 per cent.) .. .. „	2.0	2.0	2.0	2.0	2.0	2.0
Total per 1,000 kg. clinker .. .. „	343.5	343.5	370.0	370.0	182.0	343.5
Total per 1,000 kg. cement .. .. „	103.0	103.0	111.0	111.0	64.6	103.0
Load on generator, including coal grinding :—						
Per 1,000 kg. clinker .. .. kWh.	237.3	222.2	270.9	255.5	19.9	227.1
Per 1,000 kg. cement .. .. „	71.0	66.5	81.2	76.5	6.0	68.0
Requirements of power plant referred to clinker :—						
Coal consumption .. .. .. kg.	189.0	177.2	216.0	203.5	15.7	181.0
Power consumption .. .. .. kWh.	7.4	6.8	8.5	8.0	0.6	7.1
Totals, including power plant :—						
Coal per 1,000 kg. clinker .. .. kg.	532.5	520.7	586.0	573.5	197.7	524.5
Coal per 1,000 kg. cement .. .. „	159.0	156.0	175.0	171.0	59.2	157.0
Power per 1,000 kg. clinker.. .. kWh.	244.7	229.0	279.4	263.5	20.5	234.2
Power per 1,000 kg. cement .. „	74.0	69.2	84.5	79.7	6.2	70.8

coal is required. If the boilers of the generating plant are fired with powdered coal, an allowance must be made for drying and grinding this coal; 76 kg. powdered coal are required to develop 100 kWh at the generator terminals. If the raw coal contains 5 per cent. water, 4 kg. water must be evaporated per 76 kg. powdered coal, which corresponds to an additional 6,000 kcal., or 0.8 kg., standard or powdered coal. Thus, if powdered coal firing is used throughout the plant, 76.8 kg. powdered coal is necessary to produce 100 kWh at the generator terminals, for the grinding of which 3.1 kWh is required. That

is, for 100 kWh available at the terminals for use in the works, 103.1 kWh must be produced by the generating plant, and 79.2 kg. (174.6 lb.) powdered coal must be used.

Tables XIX to XXV give the power requirements of the various works and the powdered coal consumption, assuming that both the raw materials and the coal are dried by powdered coal. The following percentage moisture contents are assumed in the calculations: Raw materials, 12, coal 5, limestone (in the case of the slag cements) 5, and blastfurnace slag 30. The figure given for the coal consumption of the rotary kilns is the minimum value that can be attained in normal modern kilns under skilled control.

By multiplying the total coal consumption of the works by 0.04, the load (in kWh) on the generator due to coal grinding, is obtained. This is added to the "Load on generator, exclusive of coal grinding," to give the "Load on generator, including coal grinding." This is followed in the tables by the "Coal consumption of works power plant" calculated on the assumptions given. The tables conclude by giving the overall powdered coal consumption of the works, including its power generating plant, and the overall output of the power plant in kilowatt-hours.

In conclusion, it may again be emphasised that the tables only show typical cases, which may be modified in various directions in actual practice.

(*To be continued.*)

Notes from the Foreign Press.

ABSTRACTED BY J. W. CHRISTELOW, B.Sc.

Determination of Alkalis by the Lawrence Smith Method. C. PRÜSSING. *Zement*, Vol. 20, p. 360, 1931.

In the proposed German standard scheme for the analysis of cements the alkalis are determined by the Lawrence Smith method, the first stage of which consists in igniting a mixture of cement with ammonium chloride and calcium carbonate in platinum over a Teclu burner. The author shows that this leads to loss of alkalis by volatilisation. The oxidising cone of the Teclu burner may reach 1150 deg. C. and the inner cone 850 deg., which is sufficient to volatilise all the alkalis on long heating. Experiments in an electric resistance furnace showed that all the amm. chloride could be removed at 375 deg. without loss of alkali. KCl begins to volatilise at 500 deg. and NaCl at 560 deg. The losses are considerable at 760 deg. and complete at 900 to 1000 deg. It is concluded that the ignition temperature must not exceed 500 deg. C., and the use of an electric muffle at 375-400 deg. is recommended.

Fine Grinding and the Quality of Cements. D. STEINER. *Tonind. Zeit.*, Vol. 55, p. 672, 1931.

The author's experiments on grinding the same clinker to varying degrees of fineness show that within the limits of practical fineness for normal and high-strength cements, increased fineness results in increased tensile and crushing strengths. It is agreed that on grinding still finer a limit may be reached beyond which the strength begins to fall, but this limit is well outside the practical range of fineness. A clinker ground to (1) 11.6 and (2) 3.0 per cent. residue on the 180 sieve was mixed in proportions of 3 : 1. The strengths of the resulting cement were very close to those calculated from the strengths of the two original cements. With increased grinding, crushing strength increases more rapidly than tensile strength, as is shown by tests in which a clinker was ground to four different degrees of fineness.

Repeated Setting of Portland Cement. F. KILLIG. *Zement*, Vol. 21, p. 148, 1932.

Various Portland cements were tested after (*a*) setting in the usual way, (*b*) drying and regrinding the set cement and gauging a second time, and (*c*) powdering and gauging a third time. The set cement was dried at 65 deg. C. before grinding, and no further gypsum was added. The following table gives a selection from the results :

Cement.	Residue on 180 sieve, per cent.	Setting time (hours).		Crushing strength of 1 : 3 mortar, lb. per sq. in.			Percentage of initial strength.
		Initial.	Final.	7 days.	28 days.	28 days combined storage.	28 days combined storage.
Rotary cement I :							
Original cement	4.9	3¼	7	5,844	7,210	8,063	100
Ground Vicat pats ..	5.0	½	3	1,735	3,185	3,356	41.6
Rotary cement II :							
Original cement	4.0	3¼	7	6,029	7,565	8,475	100
Boiling test pats	6.0	1	3½	3,484	5,233	5,631	66.5
Automatic shaft kiln cement III :							
Original cement	5.1	4¼	8	4,351	5,716	6,570	100
Ground set cement ..	6.4	1	3¼	1,507	2,503	3,086	47
Rotary cement IV :							
Original cement	4.6	3½	7¼	5,873	6,968	8,134	100
Ground set cement ..	8.0	½	4	3,143	3,967	5,204	64
After third set	8.0	½	4	1,209	1,820	2,304	28
Cement 20 years under sea V :							
Original cement (1910) ..	16.0	2½	7	2,489	3,982	4,693	100
Ground set cement, no additional gypsum (1931)	7.2	¼	2½	1,081	1,536	2,247	48
Set cement ground with 2 per cent. gypsum ..	8.0	¾	3¼	2,005	2,375	3,640	78
After third set, without gypsum	8.0	½	4	839	1,294	1,635	35

It will be noted from a comparison of the results for cements I and II, that the accelerated setting due to the boiling test results in higher strength at the second set. With cement IV some difficulty was experienced at the third gauging in filling the moulds with the hammer apparatus, presumably due to extensive gel formation. Cement V had been damaged by sea water in transport, and the barrels and sacks had been sunk in 1910 to form part of a sea wall. It appears that lapse of time has no effect on the strength attained on repeated setting. The colour of the cement was lighter on setting a second time. In all cases the cement was perfectly sound on repeated setting. The setting time was reduced.

Lean mortars when reset gave only low strengths. Rich mortars, however, gave 20 to 30 per cent. of their initial strength. This was shown with a 1 : 2 mortar laid in 1888, *i.e.*, 44 years old. Thus strength on repeated setting greatly depends on the density of the mix, complete hydration being relatively rapid in a lean mix.

Effect of Additions on the Chemical Resistance of Portland Cement to Water. N. GUNDIUS-ASSARSSON. *Zement*, Vol. 21, pp. 64, 77, 1932.

The favourable effect obtained when certain materials are added to cement depends mainly on the formation of difficultly soluble compounds with the lime

set free on hydration. The best method of evaluating this effect is to make comparative tests on the powdered set cements by allowing water to percolate through the samples at a fixed rate. The lime in the water which percolates through is determined and affords a comparative value of the solubility of the cement in water. The speed of percolation must be exactly the same in all cases and must be chosen to approximate to ideal conditions. Experiments showed that the best results are obtained by taking 3g. of powdered set cement (exclusive of added materials), free from water, from which particles above 0.2 mm. diameter were removed. The best rate of water percolation is 100 c.c. in ten hours. As a standard of comparison (relative solubility unity) a pure cement is used. The CaO concentration when the concentration-time curve becomes horizontal is taken as the measure of solubility; in the case of the standard this occurs when 1,250 c.c. of water have percolated.

The following table gives comparative solubility figures for cement containing a number of added materials:

	Solubility figure.
Pure cement	1.00
,, ,, + 43 per cent. oxalic acid	0.42
,, ,, + 19 per cent. SiO_2 (of 82 per cent. water content)	0.69
,, ,, + 33.3 per cent. kieselguhr	0.60
,, ,, + 10 per cent. water-glass	0.62
,, ,, + 7.7 per cent. Al_2O_3 (added as hydrate)	1.02
,, ,, + 20 per cent. soap	1.00
,, ,, + 2.8 per cent. $CaCl_2$	1.03
,, ,, + 33.3 per cent. trass	0.89
,, ,, + 50 per cent. blast furnace slag	0.87
,, ,, + 30 per cent. As_2O_3	0.31

It will be seen that apart from oxalic acid, which is not of practical importance, only the silica (including water-glass and kieselguhr) and arsenious oxide increase the chemical resistance of the cement to any great extent.

Belgian Cement Companies' Reports.

S.A. des Ciments Portland de Vaulx et Antoing reports a net profit of 24,691 francs (£141) for the year 1931. Société Financière des Ciments S.A. ("Cimfina") reports a net profit of 2,415,502 francs (£13,803) for 1931, compared with 1,379,279 francs (£7,881) for 1930.

New Plant of the Canada Cement Company.

The Canada Cement Company has completed the installation of a wet process plant at its Port Colborne works, and a new 300-ft. kiln is now in operation. The cost is estimated to have been about 500,000 dollars (£102,880).

Italian Cement Companies' Reports.

"Italcementi" S.A. Fabbriche Riunite Cemento has declared a dividend of 15 per cent. for 1931, with a net profit of 18,540,000 Lire (£200,519). This compares with a dividend of 21 per cent. for 1930, when the net profit was 25,968,354 Lire (£280,860).

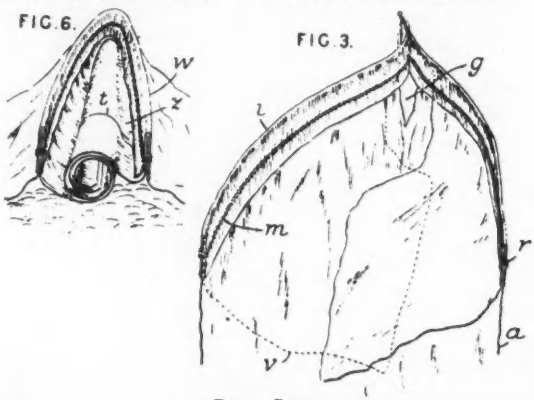
S.A. Cementi Isonzo has passed its dividend for 1931. The net profit for 1931 was 26,870 Lire (£291). This concern paid no dividend for the year 1930, when the net profit was 18,103 Lire (£196).

Recent Patents Relating to Cement.

Paper Sacks.

No. 339,938. RAWLINS, J. D., Syston Court, Mangotsfield, near Bristol, and PAPER SACKS, LTD., Keynsham, Somerset. August 14th, 1929.

In closing a paper sack or bag, stapling or stitching is provided along each side of the mouth of the open end of the bag, and may secure a thread or cord thereto at intervals, a closure being formed by threading a tie beneath the opposite portions of the stapling, stitching or thread and securing the ends of the tie in such a manner that the sides of the mouth are held together. Short slits (*g*) made in the ends of the mouth of a bag (*a*) permit reinforcing strips (*i*) to be placed over the opposite sides of the mouth. The upper edge of a tongue of flap (*v*) is inserted in the reinforcement on one or each side of the mouth and the sides, tongue and reinforcement are sewn or stapled together, a cord (*m*) being secured at intervals to the reinforcement by the sewing, etc. The strips extend beyond the edges of the bag and are secured together at their ends by reinforcements (*r*) sewn on to them. In a modification, a single reinforcing strip (*w*), fig. 6, surrounds the mouth of the bag and a single flap (*z*) having its ends secured together at (*t*) is provided. To close the bag, the flaps (*v*) or flap (*z*) are drawn upwards and rolled downwards to close the mouth as shown in fig. 6 and a tie is secured to the cords (*m*) at one end of the mouth. The tie is drawn alternately beneath the cords (*m*) until the other end of the mouth is reached, when it is drawn tight and secured to both cords. Alternatively the ends of the tie may secure the ends of the mouth in bunch form.



PAPER SACKS.

Waterproofing Cement.

No. 355,902. WINKLER, K., 398, Nordstrasse, Zürich, Switzerland. July 16th, 1930.

To increase the resistance of cement to water, a proportion exceeding 3 per cent. of cement clinker of 0.25 to 2 mm. in diameter is mixed with the finely ground cement. The clinker may be the same or of a different kind of cement from that comprising the finely ground constituent, and the final product may be obtained either by mixing the finely and roughly ground constituents or by grinding so as to obtain a suitable product. The cement, the clinker, or both may be treated with solutions of compounds of alkalis and alkaline-earth metals, for example, sodium or ammonium phosphate, compounds or solutions of fluorine compounds or solutions of oxalic acid or its salts, or are subjected to the action of the vapours of the fluorine-containing acids and then dried, more than one of the above substances being used if desired. Fillers such as sand, sandy gravel, ground building sand, powdered stone, pumice stone, tuff, slag, burnt or unburnt marl, bauxite, loam, gravel, stone, trass or kieselguhr, brick and chamotte may be added, and these may be treated with one or more of the substances mentioned above if desired, the treatment taking the place of the treatment of the rough-grained clinker. Rapid or too rapid setting is prevented by precipitating, on the clinker or other ingredients, organic or inorganic material which may be capable of swelling, such as colloidal silicic acid (silica gel), colloidal alumina, colloidal silicic acid compounds, for example, calcium silicate, gelatine, glue, albumen, decomposition

products of proteins (protalbin), casein, seaweed-glue, tragacanth, agar-agar, etc. On the other hand the setting may be accelerated by treating with solutions of metallic chlorides, alkali, and alkalin-earth lyes, silicic acid and/or aluminium compounds or permanganate. Instead of treating the ingredients with solutions of the substances mentioned above, some of them may be mixed in the dry state before, during or after burning.

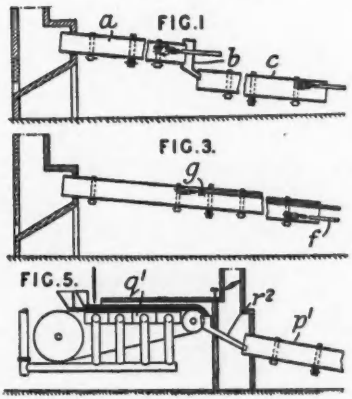
Magnesian Portland Cement.

No. 355,678. BOYNEBURG, E., 10, Priesterhausgasse, Klagenfurt, Austria. May 19th, 1930.

Magnesian Portland cement is produced by including in the mix a quantity of iron or manganese oxide which amounts to two-thirds of the magnesia in the case of a percentage of 5 per cent. magnesia and decreases to one-fifth with 40 per cent. magnesia. A table is given showing the correct amount of iron oxide to include for cements with various percentages of magnesia. The magnesia is combined in a form similar to deadburnt magnesite and to effect this an extended period of sintering of about 20 minutes which can be controlled with shaft furnaces by regulating the supply of air, or with rotary furnaces by providing an enlarged sintering zone, is given. Examples of mixes illustrating the invention are given.

Cements.

No. 356,611. MIAG MÜHLENBAU UND INDUSTRIE AKT.-GES., 4, Rathenauplatz, Frankfort-on-Main, Germany. Dec. 31st, 1930.



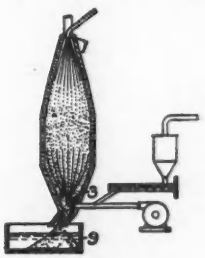
ROTARY FURNACES

A process for sintering cement consists in first heating the material to sintering temperature, then cooling slightly, again raising the temperature to complete the sintering, and finally cooling. The intermediate cooling may be carried out by passing the material through a shoot, air cooled if necessary, from one furnace to another or by lengthening a single furnace. Two furnaces of the rotary, shaft, or grate type or of different types may be used. In Fig. 1, two rotary furnaces *a*, *c* are connected by a shoot *b*. In Fig. 3, a single long rotary furnace has two burners *f*, *g* projecting different distances into the furnace, a cooling zone being formed between them. In Fig. 5, the material is heated to the beginning of the sintering process in a travelling grate furnace q^1 and is then led to a rotary furnace p^1 through a shoot r^2. Two rotary furnaces connected end to end, and a shaft furnace connected to a rotary furnace are also described and shown.

Cements.

No. 22,978. BUES, A., 1, Ritliplatz, Berlin. July 30th, 1930.

In a shaft furnace for the production of cement, lime, etc., slurry is blown into the



SHAFT FURNACE.

upper part of a shaft furnace in a downward direction to meet a mixture of fuel and air blown in an upward direction into the lower part of the furnace. As shown, the slurry is introduced through nozzle 1 and the fuel blown in with air through nozzle 3, the calcined material being received in a container 9 filled with water.

Portland Cement.

No. 24,155. ASSOCIATED PORTLAND CEMENT MANUFACTURERS, LTD., Portland House, Tothill Street, London. August 12th, 1930.

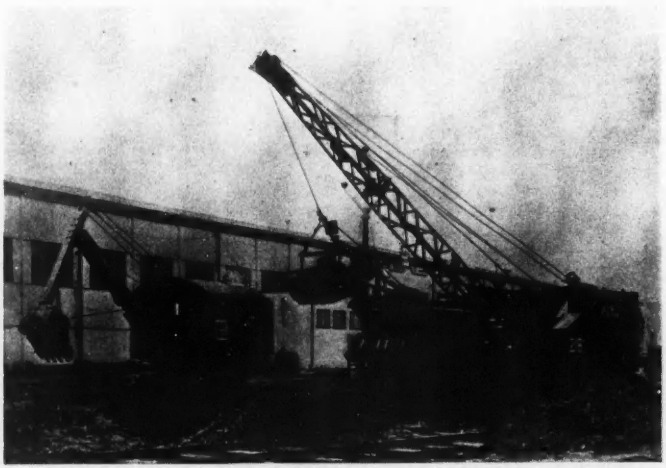
In the manufacture of cement, a substance such as coal, coke or charcoal is added to the clinker and/or raw meal as it is delivered to the tube mill or at an intermediate stage in the grinding in order to prevent clogging of the grinding members and consequent increase in temperature thereof. Coal is added to the clinker or raw meal in the proportion of 0.15-3.0 per cent.

Trade Notices.

New Range of Excavators.

THE demand for excavators with bucket capacities of more than ½ cu. yd. has led to the designing by Ruston-Bucyrus Ltd. of a range of "Universal" machines with bucket capacities varying from ½ to 2¼ cu. yds., as follows: ½ and ¾ cu. yd. shovel, dragline, dragshovel, skimmer, grabbing crane, crane, pile-driver; 1 cu. yd. shovel, dragline, dragshovel, grabbing crane, crane; 1½, 1¾, and 2¼ cu. yd. shovel, dragline, grabbing crane, crane.

The machines are practically uniform in design, and the two machines shown in the illustration, a ½-yd. machine equipped as a dragshovel and a ¾-yd. machine with dragline equipment, may be regarded as representative of the range. These machines have an improved caterpillar mounting with cast steel framing and, in all except the 2¼-yd. machine, single accessible driving shaft with final chain drive. The main axles, which do not rotate, support the weight of the superstructure; the short driving axles do not take the weight of the machine, but the travelling loads only. The 2¼-yd. machine, because of the difficulty of obtaining suitable travelling chains, has an all-gear drive.



Nearly all the machinery is behind the centre post to give the greatest possible effect as counterweight. This results in increased speed, greater mobility, low bearing pressure on caterpillars, low fuel or electricity consumption, and low working costs.

On all machines above the ½-yd. machine, continuously running shafts are mounted in ball bearings. Main transmission, swing and propelling gears, derricking gear, and the travelling gear on the caterpillars, are all fully enclosed and travel in oil. High-pressure grease fittings are piped to accessible points to ensure perfect lubrication.

For each of the excavators in this new range, except the 2¼-yd. machine, a choice of three types of motive power (Diesel engine, petrol engine, or electric motor) is provided. The 2¼-yd. machine is not supplied as a petrol machine. The Diesel engines are specially designed and manufactured for excavator service

by Ruston & Hornsby, Ltd. All the machines, except the smallest, can be supplied as either single motor or two-motor electric machines; the ½-yd. machine is supplied as a single motor machine only; the largest is also furnished as a three-motor machine or with Ward-Leonard electric control.

New Crane Regulations.

A Home Office Order came into force on November 1st last in connection with the Building Regulations in respect of cranes used in certain building operations having a fixed jib or a derricking jib. This Order calls for an automatic indicator to be fitted to all such cranes (with certain date reservations) of a type approved by the Chief Inspector of Factories. It is laid down in the Home

Office Order that all such indicators shall show clearly to the driver or person operating the crane when the load being moved approaches the safe working load of the crane at any inclination of the jib, and shall also give an efficient sound signal when the load being moved is in excess of the safe working load of the crane at any inclination of the jib. We are informed that the only indicator on the market that has so far been approved by the Chief Inspector of Factories is the Vickers-Nash safe load indicator (illustrated herewith), which is now being manufactured by Messrs. Vickers-Armstrongs, Ltd., at their Dartford works, and by the use of which practical certainty is now available instead of the judgment of a crane driver or his "slinger" as to whether a given lift may be safely undertaken. In this device the load is weighed against a spring reaction, and the resistance of the spring is in turn varied by the angle of the jib. It cannot vary in direct proportion, since the safe loads do not vary

in direct proportion; accordingly, the mechanism takes into account the crane-makers' permissible loads at the varying jib radius. The indicator is of an extremely robust and fool-proof nature, and gives accurate readings.

"Cements, Clays and Minerals."—Mr. A. L. Curtis has fulfilled a long-felt want by publishing a new magazine, entitled "Sands, Clays and Minerals," devoted to the specialist subject of economic minerals. The first number includes articles on such diverse subjects as black diamonds, ore sampling, industrial sands, slate, Portland cement, lithographic abrasives, the analysis of clay, etc., and gives a folder illustrating in colour thirty-two of the better known trade marks of cement manufacturers. The articles are all specially written for this magazine by acknowledged experts on the various subjects, and they have aroused a very keen interest in the industries concerned. The magazine is published quarterly, and the annual subscription rate is 5s. We understand specimen copies of the first number will be sent free on application to Mr. Algernon Lewin Curtis, Westmoor Laboratories, Chatteris.

Canadian Cement Output.

The output of cement for the months of January and February 1932 was 506,659 barrels, against 761,490 barrels for the same period of 1931.

Cement Production in Portugal.

The cement production of Portugal for the year 1931 was 94,829 tons, compared with 98,885 tons in 1930.

Cement Import Restrictions in Persia.

We understand that the value of the cement allowed for import into Persia under the Persian Trade Monopoly Law for the year ending June 21, 1933, has been fixed at 963,000 Krans (£10,700).

INDEX TO ADVERTISERS.

Allen, Edgar, & Co., Ltd.	—	Holman Bros., Ltd.	—
Avery, W. & T., Ltd	xvi	Hudson, Robert, Ltd.	—
Babcock & Wilcox, Ltd.	viii	Humboldt Deutzmotoren	—
British Thomson-Houston Co., Ltd.	—	Klöckner-Werke, A.-G.	ix
Brown, John, Thos. Firth & Co., Ltd.	—	Krupp Grusonwerk	xii
Chemisches Laboratorium für Tonindustrie	—	McEwan, J., & Co., Ltd.	—
Constantin, E., Ltd.	iv	Metropolitan-Vickers Electrical Co., Ltd.	—
Crompton Parkinson, Ltd.	—	"Miag" Mühlenbau und Industrie, A.-G.	—
Curtis, A. L.	—	New Conveyor Co., Ltd.	xiii
Davidson & Co., Ltd.	xv	Newell, Ernest, & Co., Ltd.	Front Cover
Davison, Charles, & Co., Ltd.	—	Pearson, E. J. & J., Ltd.	—
Diamond Lubricating Co., Ltd.	vi	Polysius, G.	—
Dowdings, Ltd.	xv	Renold & Coventry Chain Co., Ltd.	v
Evrard, F., & R. Frère	—	Richter, Oscar A.	xiv
Ewart Chain Belt Co., Ltd.	—	Rolland, John, & Co.	—
Fellner & Ziegler	vii	Ross Patents, Ltd.	—
Firth, Thos., & J. Brown, Ltd.	v	Ruston-Bucyrus, Ltd.	—
Fraser & Chalmers Engineering Works	—	Ruston & Hornsby, Ltd.	xiv
Frère, R., & F. Evrard	xvi	Seck Machinery Co., Ltd.	—
Fuller Company	—	Smidth, F. L., & Co., Ltd.	ii, iii
General Electric Co., Ltd.	—	Taylor, J. Darnley, & Co., Ltd.	—
Glover, W. T., & Co., Ltd.	—	Tonindustrie, G.m.b.H.	—
Grueber, Curt von	—	Vickers-Armstrongs, Ltd.	x, xi, xvii
Helipebs, Ltd.	xiii	Visco Engineering Co., Ltd.	—